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ORIGINAL ARTICLE

Standard vs. anatomical 180-W GreenLight laser photoselective vaporization of the prostate: a propensity score analysis

Luca Cindolo[1] · Cosimo De Nunzio[2] · Francesco Greco[3] · Paolo Destefanis[4] · Franco Bergamaschi[5] · Giovanni Ferrari[6] · Giuseppe Fasolis[7] · Fabiano Palmieri[8] · Claudio Divan[9] · Rino Oriti[10] · Lorenzo Ruggera[11] · Andrea Tubaro[2] · Claudio Dadone[12] · Gaetano De Rienzo[13] · Antonio Frattini[14] · Vincenzo Mirone[3] · Luigi Schips[1] · Members of Green Laser Italian Group

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Abstract

Purpose To compare the efficacy, safety, Patient Global Impression of Improvement (PGI-I), and complications rates after 180-W GreenLight laser (180-W GL laser) standard and anatomical photoselective vaporization (sPVP and aPVP).

Methods Within a multi-institutional database, we identified patients who underwent sPVP or aPVP to relief BPH symptoms. IPSS, Q_{max}, and prostate-specific antigen (PSA) were measured at baseline and during the follow-up. PGI-I score as well as early and late complications were recorded at follow-up visits. Log-binomial and multivariable proportional odds regression models were fitted to estimate the effect of aPVP vs. sPVP on PGI-I as well as on early and late complication rates, before and after adjustment for propensity score.

Results 813 patients were included. Of those, the 50.4% underwent aPVP. Patients who underwent aPVP had larger prostate (64 vs. 55 mL, $p < 0.001$) and higher baseline PSA levels (3.1 vs. 2.5 ng/mL, $p < 0.001$). PGI-I score was signaled as very improved, improved, slightly improved, unchanged, or worsened in 55.5, 32.8, 8.3, 2.3, and 1.2% of the cases, respectively, with no differences according the technique used ($p = 0.420$). Acute urinary retention occurred in 9.2 vs. 8.9% of patients after aPVP vs. sPVP ($p = 0.872$). All models failed to find differences in: patients' satisfaction (OR 1.19, $p = 0.256$), early complications (RR 0.93, $p = 0.387$), early urge/incontinence symptoms (RR 0.97, $p = 0.814$), and late complications rates (RR 0.70, $p = 0.053$), after aPVP vs. sPVP.

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✉ Luca Cindolo
lucacindolo@virgilio.it

[1] Department of Urology, ASL Abruzzo2, Via S. Camillo de Lellis 1, 66054 Vasto, Chieti, Italy

[2] Department of Urology, "Sant'Andrea" Hospital, Sapienza University, Rome, Italy

[3] Department of Urology, "Federico II" University, Naples, Italy

[4] Department of Urology, Azienda Ospedaliera Città della Salute e della Scienza di Torino-Sede Molinette, Turin, Italy

[5] Department of Urology, Arcispedale Santa Maria Nuova, Reggio Emilia, Italy

[6] Department of Urology, "Hesperia" Hospital, Modena, Italy

[7] Department of Urology, "S. Lazzaro" Hospital, Alba, Italy

[8] Department of Urology, Santa Maria delle Croci Hospital, Ravenna, Italy

[9] Department of Urology, Rovereto Hospital, Rovereto, Italy

[10] Department of Urology, Ulivella e Glicini Clinic, Florence, Italy

[11] Department of Urology, Clinica urologica azienda ospedaliera-University of Padova, Padua, Italy

[12] Department of Urology, "Santa Croce e Carle" Hospital, Cuneo, Italy

[13] Department of Emergency and Organ Transplantation, Urology and Andrology Unit II, University of Bari, Bari, Italy

[14] Department of Urology, "Ercole Franchini" Hospital, Montecchio Emilia, Italy

Conclusion Our results showed similar functional results and complication rates after aPVP and sPVP. However, aPVP was used in larger prostates. Both techniques guarantee high patient's satisfaction.

Keywords GreenLight laser · BPH · LUTS · Anatomical photoselective vaporization · Standard photoselective vaporization

Abbreviations

BPH/LUTS	Benign prostatic hyperplasia/lower urinary tract symptoms
180-W XPS GL laser	GreenLight XPS 180-W laser
PVP	Photo-vaporization of the prostate
sPVP	Standard PVP
aPVP	Anatomical PVP
GreenLEP	GreenLight laser enucleation of the prostate
IPSS	International Prostate Symptom Score
Q_{max}	Maximum urinary flow
PVR	Post-void residual of urine
OR	Odds ratio
RR	Relative risk
CI	Confidence interval
HoLEP	Holmium laser enucleation of prostate

Introduction

Several molecules are available to treat lower urinary tract symptoms related to benign prostatic hyperplasia (BPH/LUTS). However, a surgical approach is necessary in many situations: patients refractory to drugs, refuse/abandon of medications, and disease progression [1]. Transurethral surgery of the prostate is considered safe and effective and it is the first choice in the vast majority of patients [2–4].

Nowadays, several studies showed the safety profile of the GreenLight XPS 180-W laser (180-W XPS GL laser) [5]. European Urology Association guidelines recommend the use of GreenLight laser vaporization as the first choice in patients who cannot suspend anticoagulant/antiplatelet therapy and as an alternative to transurethral resection of the prostate (TURP) in patients with prostate volume over 80 mL [2]. However, more recently, the National Institute for Health and Care Excellence (NICE) guidelines highlighted the low level of evidence supporting such use and recommendation, especially in high-risk patients (at increased risk of bleeding or with prostates larger than 100 mL or with urinary retention) [6].

In addition, inherent limitations of 180-W XPS GL laser standard photoselective vaporization (sPVP) should be acknowledged. In particular, the extra-anatomical sPVP approach makes difficult to determine the anatomical cleavage. The latter could exert in capsule violation or residual adenoma that might require retreatment [7]. Such kinds of limitations are more evident in the treatment of large volume prostate. To overcome those limitations, anatomical PVP (aPVP) was developed, as hybrid technique in the context of the complete enucleation stepwise learning curve [7].

Nowadays, despite the wide use of aPVP [8], only one direct comparison with sPVP is available [9]. To address this void, we hypothesized that aPVP may guarantee functional outcomes, complications rates, and satisfaction level comparable to sPVP.

Materials and methods

We retrospectively reviewed multi-institutional prospectively collected data about patients treated with sPVP and aPVP using the 180-W XPS GL system (2011–2016). All aPVP were performed as of 2014. All the surgeons were expert member of Green Laser Italian Group. All patients provided a written informed consensus for surgery in all the 14 Italian centers. Patients with history of prostate cancer, neurological diseases, as well as those who underwent contemporary urethrotomy, cystolithotripsy, and with incidental bladder tumors were excluded.

Surgical procedures were performed, according to surgeon preferences, as previously described [7, 10, 11]. In short, both techniques started with visualization of ureteral orifices and the exclusion of bladder tumors. In sPVP after the creation of a working space at 5 and 7 o'clock, the prostate was vaporized in circumferential manner from the prostatic urethra towards the prostatic capsule (inside out). Differently, in aPVP after the localization of the capsule at the apex of the adenoma, the surgeon carried out a bilateral incision lateral to verumontanum and using the tip of resectoscope practice a mechanical dissection of the tissue. The dissection plane is followed towards the bladder neck at 6 o'clock and the dissection is accompanied to the vaporization, that is made firing the laser in direction of prostatic urethra (outside in). Depending on the center, a 24.5-Ch (Richard Wolf, Germany) or 26-Ch (Karl Storz, Germany) resectoscope with a laser bridge were used. In both techniques, all the tissues were vaporized and morcellation was not necessary.

Antibiotic prophylaxis was administered to all patients according to local protocols. Age and medical history, including pre-operative drugs treatment for LUTS/BPH and antiplatelet/anticoagulant therapy history, were gathered. Prostate-specific antigen (PSA), International Prostate Symptom Score (IPSS), maximum urinary flow (Q_{max}), and indwelling catheter history were collected

before surgery. Entire prostate volume was evaluated with transrectal ultrasound (TRUS).

Intra- and peri-operative data, including anaesthesia type, operative time, lasing time, energy used, catheterization time, and post-operative stay were prospectively collected. Energy density was coded as energy used divided the prostate volume. All the patients were recalled and underwent to an ambulatory visit at least after 3 months and then annually. Follow-up was calculated as time from surgery to last visit. During follow-up visit, symptoms score (IPSS), uroflowmetry (Q_{max}) parameters, and PSA level were recorded. Patient Global Impression of Improvement (PGI-I) was evaluated with PGI-I scale [12]. Complications were collected and classified as early (within 30 post-operative days) or late (after 90 days). Early complications were classified according to Clavien–Dindo classification [13, 14]. Urinary incontinence was defined as reported incontinence of any degree if bothersome and impairing patient quality of life.

Continuous variables were reported as either mean and standard deviation (SD) or median and interquartile (IQR) range on the basis of their distribution (assessed using Shapiro–Wilk test). Comparison of variables between groups was performed by unpaired Student *t* test or Mann–Whitney *U* test according to their distribution. Categorical variables were expressed as absolute number and percentage and analyzed by Chi-square test. Differences between PVP interventions were estimated using propensity scores to adjust for the bias inherent to the different patient characteristics. The propensity scores (PS) were estimated by fitting a logistic regression model with PVP intervention as dependent variable. The covariates included in the PS models were age, prostate volume, baseline PSA, BPH/LUTS therapy, antiplatelet/anticoagulant therapy, and indwelling catheter history. Quintiles of the estimated PS were also calculated. Main outcomes were: patient's reported improvement of urinary symptoms evaluated with PGI-I scale, overall early complications, early urge/incontinence symptoms, and overall late complications. For each outcome related to the incidence of complications, three different log-binomial regression models were fitted to estimate unadjusted effect of PVP intervention, adjusted effect adding in the model a linear term of PS, and the third model adding in the model quintile categories of PS. Multivariable proportional odds regression model was performed to analyze PGI-I values, using the same approach previously reported to compare PVP interventions and using a score test to verify the proportional odds assumption of the model [15]. A two-tailed p value < 0.05 was considered significant. Data were analyzed using SAS version 9.4 (SAS Inc., Cary, NC).

Results

Baseline characteristics and intra- and peri-operative outcomes

Of 813 patients included, the 50.4% underwent aPVP. The baseline prostate volume ranged between 14.0 and 268.0 mL (IQR 46.0–80.0). Patients who underwent aPVP had larger prostate (64 vs. 55 mL, $p < 0.001$) and higher baseline PSA level (3.1 vs. 2.5 ng/mL, $p < 0.001$) than those who underwent sPVP (Table 1). Median follow-up duration was 17.7 (12.0–25.8) months. The median follow-up duration was significantly shorter for patients who underwent aPVP (15.1 vs. 18.8 months, $p < 0.001$). aPVP required a slightly longer operative time (60 vs. 56 min, $p = 0.023$), longer laser time (28 vs. 23 min, $p < 0.001$), and higher energy used (269 vs. 208 kJ, $p < 0.001$) (Table 1).

Efficacy and safety

At 6 months was recorded a significant improvement in terms of ΔIPSS (− 15, IQR − 19 to − 10) and ΔQ_{max} (+ 10, + 7 to + 14). Overall, 96.7% of patients answered to PGI-I questionnaire with comparable results among aPVP and sPVP (Table 2). In multivariable proportional odds regression models, surgical technique (aPVP vs. sPVP) was not predictive of patient satisfaction, also after PS adjustment (OR 1.19, CI 0.88–1.61, $p = 0.256$) (Table 3).

The overall early complications rate was 46.4% (45.9 vs. 47.0% in respectively sPVP vs. aPVP). According to Clavien–Dindo classification, 89.8% of complications were grade I, with no statistically significant differences between surgical techniques ($p = 0.575$) (Table 4). In log-binomial regression models, surgical technique (aPVP vs. sPVP) was not predictive of overall early complications (RR 0.93, CI 0.79–1.10, $p = 0.387$) as well as of early urge/incontinence symptoms (RR 0.97, CI 0.74–1.27; $p = 0.814$), also after PS adjustment (Table 3).

The overall late complications rate was 16.6% (17.7 vs. 15.5% in respectively sPVP vs. aPVP). Despite, a second intervention was necessary in 3.1% of patients; only one sPVP patient required the implant of a prosthesis for urinary incontinence (Table 4). In log-binomial regression models, surgical technique (aPVP vs. sPVP) was not predictive of late complications (RR 0.70, CI 0.48–1.01, $p = 0.053$) (Table 3).

Discussion

In our retrospective study, we compared aPVP and sPVP. Our results showed several important findings. First, aPVP represent the 50% of all procedures and it is considered as

Table 1 Patient's pre-operative and intra-operative characteristics

	Overall ($n = 813$)	Standard PVP ($n = 403$)	Anatomical PVP ($n = 410$)	p value
Pre-operative variables				
Age (years)	69.3 ± 8.4	69.7 ± 8.5	69.0 ± 8.3	0.235
Prostate volume (TRUS) (mL)	60 (46–80)	55 (42–76)	64 (50–81)	< 0.001
Prostate volume ranges	14–268	22–268	14–250	
Baseline PSA (ng/mL) (missing = 59)	2.8 (1.6–4.3)	2.5 (1.3–3.9)	3.1 (1.9–4.5)	< 0.001
Baseline IPSS (missing = 135)	23 (19–27)	23 (19–27)	23 (20–27)	0.076
Baseline Q_{max} (mL/s) (missing = 123)	8.7 (7.0–10.2)	8.2 (7.0–10.0)	9.0 (7.0–10.9)	0.301
BPH/LUTS therapy (missing = 14)				0.821
None	142 (17.8)	71 (17.7)	71 (17.8)	
Alpha-blockers	388 (48.6)	191 (47.6)	197 (49.5)	
5-ARI	51 (6.4)	24 (6.0)	27 (6.8)	
Combination	218 (27.3)	115 (28.7)	103 (25.9)	
Antiplatelet/anticoagulant therapy (missing = 47)				0.449
None	455 (59.4)	226 (59.3)	229 (59.5)	
Antiplatelet	231 (30.2)	120 (31.5)	111 (28.8)	
Anticoagulant	80 (10.4)	35 (9.2)	45 (11.7)	
Indwelling catheter history (missing = 33)				0.085
No	638 (81.8)	334 (84.1)	304 (79.4)	
Yes	142 (18.2)	63 (15.9)	79 (20.6)	
Intra-operative variables				
Anaesthesia (missing = 20)				0.055
General	97 (12.2)	38 (9.9)	59 (14.4)	
Spinal or epidural	696 (87.8)	345 (90.1)	351 (85.6)	
Operative time (min) (missing = 128)	60 (40–75)	56 (40–70)	60 (45–80)	0.023
Lasing time (min) (missing = 115)	25 (18–36)	23 (16–33)	28 (20–38)	< 0.001
Energy used (kJ)	240 (170–356)	208 (150–322)	269 (190–376)	< 0.001
Energy used (kj)/prostate volume (TRUS) (mL)	4.15 (2.99–5.38)	3.80 (2.86–5.08)	4.49 (3.11–5.57)	0.001
Energy used (kJ)/prostate volume (TRUS) (mL) > 3	589 (73.8)	280 (70.9)	309 (76.7)	0.063
Catheterization time (days)	1 (1–2)	1 (1–2)	1 (1–2)	0.082
Post-operative stay (days)	2 (1–3)	2 (1–3)	2 (1–2)	0.25

Table values are *n* (%) or mean ± SD or median (IQR)

PVP photoselective vaporization of the prostate, *TRUS* transrectal ultrasonography, *PSA* prostate-specific antigen, *IPSS* International Prostate Symptoms Score, *5-ARI* 5-alpha redeuctase inhibitors

an alternative to sPVP [8]. This finding may reflect the current trend to skip to endoscopic enucleo-vaporization and enucleation of the prostate independently from the energy sources used [16]. Second, aPVP vs. sPVP offers comparable functional outcomes, complication rates, and PGI-I score.

It is noteworthy that aPVP required a statistically significant, but not clinically meaningful, longer operative, and lasing time despite its use in significantly larger prostates. In aPVP, the direction of the laser energy (outside in) allows to save the bladder neck, the capsule and peri-capsular vascular-nervous bundle resulting in a similar rate of early and late complications, despite the longer lasing time and the higher amount of energy required to treat larger prostates [8]. Moreover, the efficacy of aPVP in larger prostate treatment is validated by the post-operative PSA drop that was greater in aPVP vs. sPVP (− 1.5 vs. − 1.0 ng/mL, $p < 0.001$). Such difference may reflect the larger amount of tissue removed [17, 18] that could not be directly evaluated for the absence of tissue retrieved.

Our results partially corroborate those by Hibon et al. where in a smaller cohort (106 vs. 813 patients of this study) highlighted no significant differences in terms of hospital stay, time of catheterization, IPSS, Q_{max}, and PVR between sPVP and aPVP. Nevertheless, they showed significant higher rates of stress urinary incontinence using aPVP [9]. Authors hypothesized that this difference may be due to the larger surgical confidence with sPVP than with a novelty as aPVP. Moreover, Hibon et al. recorded a shorter follow-up than the present study, both for sPVP

Table 2 Main outcome results

	Overall ($n = 813$)	Standard PVP ($n = 403$)	Anatomical PVP ($n = 410$)	p value
Follow-up duration (months)	17.7 (12.0–25.8)	18.8 (14.0–24.6)	15.1 (9.3–26.8)	< 0.001
Δ IPSS (6 months) (missing = 224)	− 15 (− 19 to − 10)	− 15 (− 18 to − 10)	− 16 (− 20 to − 11)	0.018
ΔQ_{max} (6 months) (missing = 240)	10 (7–14)	10 (6–13)	11 (8–14)	0.085
ΔPSA (6 months) (missing = 363)	− 1.2 (− 2.4 to − 0.4)	− 1.0 (− 2.1 to − 0.2)	− 1.3 (− 2.3 to − 0.6)	0.007
ΔPSA (last available) (missing = 199)	− 1.2 (− 2.4 to − 0.4)	− 1.0 (− 2.1 to − 0.2)	− 1.5 (− 2.5 to − 0.6)	< 0.001
Acute urine retention (missing = 59)	68 (9.0)	34 (8.9)	34 (9.2)	0.872
Overall early complications (missing = 31)	363 (46.4)	183 (45.9)	180 (47.0)	0.751
Early urge/incontinence symptoms (missing = 31)	194 (24.8)	96 (24.1)	98 (25.6)	0.621
Clavien–Dindo classification of early complications				0.575
I	326 (89.8)	163 (89.1)	163 (90.6)	
II	22 (6.1)	10 (5.5)	12 (6.7)	
IIIa	3 (0.8)	1 (0.5)	2 (1.1)	
IIIb	3 (0.8)	2 (1.1)	1 (0.6)	
IVa	8 (2.2)	6 (3.3)	2 (1.1)	
V	1 (0.3)	1 (0.5)	0 (0)	
Overall late complications (missing = 49)	127 (16.6)	70 (17.7)	57 (15.5)	0.417
Patient global impression of improvement (missing = 27)				0.420^
Very improved	436 (55.5)	214 (54.2)	222 (56.8)	
Improved	258 (32.8)	128 (32.4)	130 (33.3)	
Slightly improved	65 (8.3)	36 (9.1)	29 (7.4)	
Unchanged	18 (2.3)	10 (2.5)	8 (2.1)	
Worse	9 (1.2)	7 (1.8)	2 (0.5)	

Table values are *n* (%) or median (IQR)

PVP photoselective vaporization of the prostate, *IPSS* International Prostate Symptoms Score, *PSA* prostate-specific antigen

^Trend test *p* value 0.124

Table 3 Estimates of comparison (anatomical PVP vs. standard PVP) of the main outcomes

	Unadjusted (95% CI) p value	PS adjusted (linear term) (95% CI) p value	PS adjusted (quintiles) (95% CI) p value
Patients perception of improvement satisfaction, OR	1.16 (0.88–1.52) 0.283	1.19 (0.88–1.61) 0.256	1.22 (0.90–1.65) 0.200
Overall early complications, RR	1.03 (0.88–1.19) 0.751	0.93 (0.79–1.10) 0.387	0.94 (0.80–1.12) 0.493
Early urge/incontinence symptoms, RR	1.06 (0.83–1.36) 0.621	0.97 (0.74–1.27) 0.814	0.99 (0.76–1.31) 0.967
Overall late complications, RR	0.88 (0.64–1.21) 0.418	0.70 (0.48–1.01) 0.053	0.74 (0.51–1.06) 0.101
Overall late complications, RR^	0.90 (0.61–1.32) 0.598	0.69 (0.44–1.06) 0.090	0.72 (0.46–1.12) 0.150

PVP photoselective vaporization of the prostate, *CI* confidence interval, *PS* propensity score, *OR* odds ratio, *RR* relative risk

^Adjusted for follow-up duration

(9.3 vs. 18.8 months) and aPVP (3.8 vs. 15.1 months). This may justify the higher rate of stress urinary incontinence that may be temporary [9]. In fact, in our analyses, all the models failed to find higher rates of early urge and or incontinence symptoms. We relied on models that specifically tested these outcomes and not only the overall early complications rates because of the clinical importance of bothersome symptoms.

Furthermore, Stone et al. reported a significant improvement in terms of subjective and objective parameters using a 180-W XPS GL laser using a vapo-enucleation technique in patients with prostate volume over 150 mL. They also reported mostly Clavien grade I/II complication with a dysuria rate of 7.1%. The re-intervention rate was of 2.9% [19].

In summary, our results confirm the versatility of 180-W XPS GL laser that allow to tailor the surgery according to

Table 4 Early and late complications stratified according to PVP techniques

Onset of adverse events	Adverse events	Frequency of adverse events *n* (%)		
		Overall	Standard PVP	Anatomical PVP
Early complications (missing = 31)	Fever < 38 °C	18 (2.3)	5 (1.3)	13 (3.4)
	Fever > 38 °C	33 (4.2)	22 (5.5)	11 (2.9)
	Burning urination	123 (15.7)	56 (14.0)	67 (17.5)
	Frequency	62 (7.9)	20 (5.0)	42 (11.0)
	De novo urge	84 (10.7)	34 (8.5)	50 (13.1)
	De novo urge incontinence	57 (7.3)	35 (8.8)	22 (5.7)
	Stress incontinence	36 (4.6)	23 (5.8)	13 (3.4)
	Capsule perforation	5 (0.6)	3 (0.8)	2 (0.5)
	Haematuria	26 (3.3)	17 (4.3)	9 (2.4)
	Acute urinary retention	72 (9.2)	37 (9.3)	35 (9.1)
	Urinary tract infection	15 (1.9)	5 (1.3)	10 (2.6)
	Blood transfusions	6 (0.7)	3 (0.8)	3 (0.8)
	Minor cardiovascular event[a]	5 (0.6)	1 (0.3)	4 (1.0)
	MACE	8 (1.0)	6 (1.5)	2 (0.5)
	Death	1 (0.1)	1 (0.3)	0 (0.0)
	Overall early complications	363 (46.4)	183 (45.9)	180 (47.0)
Late complications (missing = 49)	Urethral stenosis	20 (2.6)	13 (3.3)	7 (1.9)
	Bladder neck contracture	21 (2.8)	16 (4.0)	5 (1.4)
	Prostatic fossa sclerosis	10 (1.3)	7 (1.8)	3 (0.8)
	Stress incontinence	32 (4.2)	18 (4.6)	14 (3.8)
	Re-intervention	24 (3.1)	16 (4.0)	8 (2.2)
	Persistent irritative symptoms	41 (5.4)	17 (4.3)	24 (6.5)
	Death	5 (0.7)	3 (0.8)	2 (0.5)
	Overall late complications	127 (16.6)	70 (17.7)	57 (15.5)

MACE major adverse cardiovascular events (angina pectoris, acute myocardial infarction, other chronic ischemic heart disease, transient ischemic attack, cerebrovascular events or deep venous thrombosis, as well as pulmonary embolism)

[a]All the events that are not considered as MACE

surgeon's skills and patient's characteristics (in particular prostate volume) without harm functional results or safeness profile. All models failed to find differences in patients' satisfaction, early complications, and late complications rates after aPVP vs. sPVP. Should be noted that aPVP could be used in larger prostates, overcoming the major limitation of sPVP. Moreover, aPVP warranted a greater PSA drop, which reflects the larger amount of removed tissue. Finally, our results confirmed the safety and efficacy of both techniques as well as the high rate of patients referring their condition as very improved (55.5%) or improved (32.8%).

Despite the large multi-institutional cohort representative of Italian reality, the use of validate questionnaire to assess self-reported improvement perception, and the use of PS based statistics to control selection biases, our analysis is not devoid of limitations: first, the retrospective and not-randomized design; second, different surgical experience and different operator involvement could not be controlled in the analytic phase. Third, pre-operative and post-operative patients' management was not standardized. Fourth, the complications assessment and management (as re-intervention) may vary according the different centers. Fifth, in our analyses, as in previous reports on GL-180 W laser [20–22], the length of follow-up limited the possibility to observe long-term complication. The latter may affect observed rate differences and results. Finally, information on the number of fiber used were partially available and thus were excluded from any further consideration.

Conclusion

In this large real-life experience, aPVP, despite used in larger prostates, achieves results similar to the sPVP. Moreover, both techniques guarantee the same clinical outcome and high patient's satisfaction.

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Compliance with ethical standards

Conflict of interest LC, LR, PD, CD, and GF do surgical tutorship for AMS and received honoraria for their tutorship.

Ethical approval For this type of study, formal consent is not required.

Informed consent Informed consent was obtained from all individual participants included in the study. This study and all the related procedures have been performed in accordance with the Declaration of Helsinki.

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