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ARTICLE

Step-by-step anatomical photovaporization of the prostate using 180-W XPS greenlight laser: optimizing functional outcomes through energy modulation

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Background: *The surgical management of patients with benign prostatic hyperplasia (BPH) has considerably evolved through recent years. Nonetheless, benefits and harms of several laser procedures are still to be determined. The study aimed to report perioperative and early functional results of patients treated with anatomical photo vaporization of the prostate (aPVP).*

Methods: *Data from consecutive patients treated with aPVP by using a 180-W XPS GreenLight laser were prospectively collected in a single tertiary center between 2020 and 2023. The surgical procedure was divided into a modular step-by-step fashion. Patients were asked to complete self-administered questionnaires at baseline and during follow-up visits.*

Results: *Overall, 176 consecutive patients were enrolled. Median age was 65 [interquartile range (IQR) 63–72] years. The baseline median prostate volume was 61.2 (IQR 52.5–71.0) mL, and the median max flow rate (Q_{max}) was 9.3 (IQR 7.8–11.5) mL/s. Median preoperative International Prostate Symptom Score (IPSS) was 25 (IQR 22–29). Overall, the median operative time was 42 (IQR 31–47) minutes with a median energy/mL of tissue delivered of 2447 kJ/mL. At 3 month-evaluation, significant improvements were observed, with a median Q_{max} of 28 (IQR: 24–32) mL/s and a median IPSS reduction of 15 (IQR: 11–18) points. A strong inverse correlation was identified between energy delivery during initial procedural steps and the severity of postoperative storage symptoms (all $p < 0.05$), underscoring the importance of precise energy modulation. Multivariate analysis identified increased prostate volume (odds ratio [OR]: 1.02; 95% confidence interval [CI] 1.01–1.11; $p = 0.001$) and higher prostate width-to-length ratio (OR: 1.28; 95% CI 1.04–1.78; $p = 0.03$) as independent predictors of increased energy requirements.*

Conclusions: *aPVP with 180-W XPS GreenLight laser is a safe and effective technique showing worthy early functional results. The limitation of the energy delivered in some key phases of the procedure may be associated with a significant reduction in postoperative irritative symptoms. The shape and dimensions of the prostate also play a critical role in determining the total energy required for complete adenoma removal.*

Key Words: anatomical, green, laser, vaporization, prostate

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Introduction

Benign prostatic hyperplasia (BPH) is a condition characterized by the overgrowth of epithelial and stromal cells, leading to enlargement of the prostate, particularly in the periurethral zone. This condition appears to be the main cause of lower urinary symptoms (LUTS) in patients with advanced age, ultimately leading to both storage and voiding disturbances.[1] Whenever the symptoms do not improve with medical therapy, patients can be offered different surgical options. To date, transurethral resection of the prostate (TURP) still represents the gold standard surgical treatment for BPH patients.[2] Nonetheless, in recent years, different lasers have been introduced to treat BPH and at the same time reduce the likelihood of postoperative complications, including perioperative bleeding.[3–5] Among these, the GreenLight laser appears as a useful device to perform photovaporization of the prostate (PVP).[6–9]

The GreenLigh laser system for BPH relies on a continuous electrical current supply, which excites the medium inside the laser (such as calcium-titanyl phosphate crystals) to produce light at the specific 532 nm wavelength, corresponding to the green region of the visible light spectrum. This wavelength is highly absorbed by hemoglobin in the blood, so that the water content of the cell is heated up to the point of vaporization when the laser hits the tissue.[10] This explains why this procedure obtains vaporization and coagulation of the tissue at the same time, thus being particularly beneficial for patients with multiple comorbidities or taking antiplatelet/anticoagulant (AP/AC) therapy.[11]

Since it was first introduced, several works have focused on proving the efficacy of PVP in terms of functional outcomes, but so far, there has been no definitive consensus on optimal surgical technique.[5] Moreover, different techniques can be associated with different total amounts of energy delivered to the prostate,[12,13] which in turn may influence early postoperative irritative symptoms.

This study describes anatomical PVP (aPVP), a technique for treating BPH by wisely alternating both vaporization and mechanical dissection of the adenoma in order to minimize the total amount of energy delivered. In particular, we sought to investigate whether energy modulation in some key steps may be beneficial in improving perioperative outcomes. Additionally, we explored the clinical and surgical factors associated with increased energy delivery during the procedure.

Materials and Methods

Patient selection and dataset

After institutional review board approval, clinical and surgical data from consecutive patients treated between 2020 and 2023 with anatomical PVP by using 180-W XPS GreenLight™ (Boston Scientific, Marlborough, MA, USA), in a single tertiary center (Careggi University Hospital), were gathered. Informed consent was obtained from all individual participants included in the study. Inclusion criteria were: 1) symptomatic BPH not responsive to medical therapy; 2) preoperative max flow rate (Q_{max}) at flowmetry < 15 mL/s and/or post-void residual (PVR) > 100 mL; 3) prostate volume < 100 cc. Patients with a prostate-specific antigen (PSA) level ≥ 4 ng/mL or suspicious digital rectal examination (DRE) underwent multiparametric magnetic resonance imaging (mpMRI) to exclude concomitant prostate cancer. Those with persistent clinical or imaging suspicion of malignancy were excluded. Preoperative assessments included age, sex, body mass index (BMI), and comorbidity status, evaluated using the Charlson Comorbidity Index (CCI) and the American Society of Anesthesiologists (ASA) physical status classification. All patients underwent baseline laboratory and imaging evaluations, including serum PSA, uroflowmetry with PVR measurement, and abdominal ultrasound (US). The width-to-length ratio (WLR) of the prostate was calculated using preoperative imaging data, typically derived from the transabdominal US. The length of the prostate was measured from the base to the apex along the sagittal plane, while the width was measured as the maximum transverse diameter in the axial plane. The WLR was classified into three categories: low if <0.8, moderate if between 0.8 and 1.2, and high if >1.2.[14] Postoperative complications were classified according to the modified Clavien-Dindo grading system.[15] All procedures performed in this study involving human participants were by the ethical standards of the institutional and national research Committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Institutional review board approval (IRB 23022/22) from Careggi University Hospital was obtained.

Surgical technique

A detailed illustration of the surgical techniques employed at our Institution (Careggi University Hospital) for aPVP can be found in Figure 1. After the patient is placed in the lithotomy position, the continuous flow 26 Ch resectoscope (Karl Storz, Tuttlingen, Germany) fitted with a classical 30-degree optic is

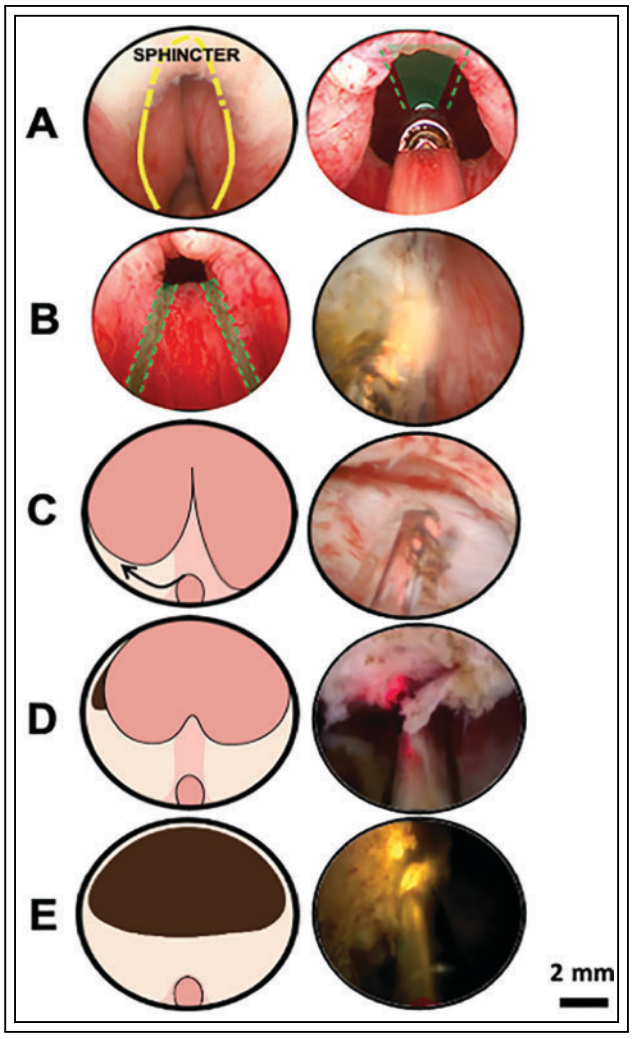

FIGURE 1. Surgical steps of aPVP. A) Identification of anatomical landmarks such as the external urethral sphincter and creation of an irrigation channel at 12 o'clock; B) Moving the laser fiber from the bladder neck to the prostate apex, landmark demarcation at 5 and 7 o'clock; C) Prostate capsule plane development at the level of the apex and prostate floor treatment; D) Mechanical dissection of the adenoma is completed by advancing the resectoscope in an antegrade direction, from the apex to the bladder neck; E) Treatment of the apex

employed. The surgical procedure is divided into 5 steps according to our previous standardized protocol [16]: 1) Vaporization begins at noon on the medial surface of both lateral lobes to create a concave irrigation channel through which air bubbles, created when the laser heats tissue and blood, can exit the prostate gland into the bladder; 2) moving the laser fiber from the bladder neck to the prostate apex, two grooves are incised at 5 and 7 o'clock until the surgical capsule has been exposed and identified by its white transverse fibrous characteristics, as compared to the yellow/brown adenoma tissue; 3) at the apex, the tip of the resectoscope is used to localize the capsule plane and prostate floor tissue treatment is performed; 4) mechanical dissection of the adenoma is completed by advancing the resectoscope in an antegrade direction, from the apex to the bladder neck, thus developing an anatomical plane between adenoma and capsule. The adenomatous tissue, once mobilized, remains in place and is vaporized *in situ* using the 180-W XPS GreenLight; 5) if residual adenomatous tissue remains attached to the apex, further vaporization is carried out at 12 and at 2 o'clock to prevent a valve-like mechanism. All procedures were performed by surgeons who had already completed the learning curve for aPVP and had full proficiency in the five-step anatomical technique, ensuring consistency and minimizing operator-dependent variability.

Outcome measures and follow-up

Assessment visits—including uroflowmetry and PVR measurement via abdominal ultrasound—were conducted at baseline (day 0) and subsequently at 3, 6, and 12 months following the surgical procedure. In the current study, by concentrating on the 3-month follow-up, we aimed to capture a more stable assessment of symptom resolution and functional recovery. In particular, the choice of this time frame reflects the typical progression of tissue healing and the subsidence of thermal effects from the laser. This approach allowed us to evaluate the sustained benefits of aPVP while accounting for the transient nature of potential early postoperative irritative symptoms. Clinical evaluation was assessed using the Italian version of the following validated questionnaires: International Prostate Symptom Score (IPSS),[17] Overactive Bladder Questionnaire (OAB-q),[18] International Consultation on Incontinence Questionnaire-Short Form (ICIQ-SF)[19] and the International Index of Erectile Function (IIEF)-5.[20]

Statistical analysis

Continuous variables were summarized using median and interquartile range (IQR). Group comparisons were performed using the Student's independent *t*-test for normally distributed variables and the Mann-Whitney U-test for non-normally distributed data, with normality assessed by the Kolmogorov-Smirnov test. Categorical variables were analyzed using the Chi-square test. Changes in clinical parameters from baseline to follow-up

were evaluated by calculating median differences and applying non-parametric statistical tests. The association between the energy delivered and persistent postoperative symptoms (Δ-IPSS, IIEF, QoL, OABQ-SF, ICIQ-SF) was assessed using the Pearson correlation. To explore predictors of increased energy delivery, a logistic regression model was built using a predefined threshold (≥3500 kJ/mL) as the dependent variable, corresponding to the third quartile for median energy/mL of tissue delivered. Variables were included based on prior evidence of clinical impact on perioperative and functional outcomes in BPH surgery. To reduce model complexity and multicollinearity, backward stepwise elimination was applied as a secondary step. Statistical analyses were performed using STATA 16 (Stata Corp., College Station, TX, USA). All tests were two-sided, with significance set at $p < 0.05$.

Results

Overall, 176 consecutive patients were enrolled. Table 1 shows in detail the preoperative, surgical, and early postoperative features of the entire cohort. Median age was 65 (IQR 63–72) years and median ASA score was 2 (IQR 2–3). The baseline median prostate volume was 61.2 (IQR 52.5–71.0) mL, and the median Q_{max} was 9.3 (IQR 7.8–11.5) mL/s. The median WLR was 1.10 (IQR 1.05–1.25). Median preoperative IPSS, OAB-q, ICIQ-SF, IIEF-5, and QoL scores were 25 (IQR 22–29), 61 (IQR 54–66), 0 (IQR 0–1), 20 (IQR 16–23) and 4 (IQR 4–5), respectively. Overall, the median operative time was 42 (IQR 31–47) min with a median lasing time of 20 (IQR 15–24) min. The median energy/mL of tissue delivered was equal to 2447 kJ/mL (IQR 1545–3624). More in detail, median energy delivered was 159 (IQR 100–235), 670 (IQR 423–992), 824 (IQR 520–1220), 487 (IQR 307–721), and 307 (IQR 193–454) kJ/mL after dividing the procedure from step 1 to 5, respectively. No intraoperative complications were recorded. Four (2.3%) patients experienced early postoperative complications (one perioperative bleeding requiring blood transfusion and three postoperative acute urinary retentions requiring catheterization). One (0.6%) patient experienced delayed postoperative complications, namely postoperative urethral stricture requiring endoscopic urethrotomy. Median catheterization and hospitalization time were 2 (IQR 2–3) days. At the 3-month assessment, the median Q_{max} was 28 (24–32) mL/s. A postoperative improvement in both storage symptoms and global satisfaction was recorded (median ΔIPSS, ΔOABq, and ΔICIQ-SF were 15, 33, and 0, respectively), with the benefit maintained also at 6- and 12-month assessment (Table 2). A significant inverse correlation between the amount of energy delivered and improvement in storage symptoms (as assessed by ΔOAB-q and ΔIPSS) was found for steps 1 to 3 (all $p < 0.05$), while no significant associations were found between energy/mL used in steps 4–5 and ΔOABq ($p = 0.12$ and 0.10, respectively). At univariate analysis, increasing ASA score ($p = 0.02$), age-adjusted CCI ($p = 0.02$), AP/AC therapy ($p = 0.01$), increasing preoperative prostate volume ($p < 0.001$), and high WLR ratio ($p = 0.02$) were significantly associated to an increased (>3500 kJ/mL) amount of energy delivered. At multivariate analysis, increased prostate volume (OR: 1.02; 95% confidence interval [CI] 1.01–1.11; $p = 0.001$) and high WLR (1.28; 95% CI 1.04–1.78; $p = 0.03$) remained the only independent predictors of higher amount of energy delivered (Table 3). At a median follow-up of 17 (IQR 12–22) months, the procedure demonstrated a favorable mid-term safety profile with no cases of bladder neck contracture or reoperation for BPH.

Discussion

The results of this study highlight the clinical efficacy of aPVP using the 180-W XPS GreenLight in the treatment of BPH.[21,22] At the 3-month evaluation, significant improvements were observed in both objective measures and subjective patient-reported outcomes, with the benefit maintained also at the one-year evaluation. These findings underscore the potential of this technique as a minimally invasive alternative to traditional TURP. Recent evidence further pointed to PVP achieving shorter catheterization times and hospital stays with lower rates of sexual dysfunction and bleeding-related complications as compared to TURP.[23,24] One of the most compelling aspects of aPVP is its exceptional safety profile. The procedure effectively minimizes perioperative risks, a notable achievement for patients with significant comorbidities or those taking AP/AC therapy, as corroborated by recent evidence.[25,26] These individuals, often excluded from traditional interventions like TURP due to bleeding risks, were safely included in this study, with no major bleeding complications recorded. The low incidence of complications in our series highlights the safety profile of aPVP. Indeed, the GreenLight laser dual mechanism—tissue vaporization coupled with immediate coagulation—was pivotal in achieving this outcome, as evidenced by a

TABLE 1. **Preoperative, surgical and early postoperative features of 176 patients treated with aPVP**

Preoperative characteristics		
Age (years) (median, IQR)		65 (63–72)
BMI (kg/m^2) (median, IQR)		26 (25–27)
ASA score (median, IQR)		2 (2–3)
AP/AC therapy at surgery (n, %)		42 (23.8)
Prostate volume (mL) (median, IQR)		61.2 (52.5–71)
WLR (median, IQR)		1.10 (1.05–1.25)
Creatinine serum level (mg/dL) (median, IQR)		0.9 (0.8–1.2)
Hb blood level (g/dL) (median, IQR)		14.2 (12.7–15.2)
Q_{max} (mL/s) (median, IQR)		9.3 (7.8–11.5)
PVR volume (mL) (median, IQR)		75 (57–130)
PSA serum level (ng/mL) (median, IQR)		3.7 (2.50–4.65)
IPSS score (median, IQR)		25 (22–29)
IIEF-5 score (median, IQR)		20 (16–23)
OAB-q score (median, IQR)		61 (54–66)
ICIQ-Sf score (median, IQR)		0 (0–1)
QoL score (median, IQR)		4 (4–5)
Surgical Outcomes		
Overall operative time (min) (median, IQR)		42 (31–47)
Lasing time (min) (median, IQR)		20 (15–24)
Energy delivered (kJ/mL) (median, IQR)	Total	2447 (1545–3624)
	Step 1	159 (100–235)
	Step 2	670 (423–992)
	Step 3	824 (520–1220)
	Step 4	487 (307–721)
	Step 5	307 (193–454)
Conversion to TURP (n, %)		0 (0)
Conversion to open adenomectomy (n, %)		0 (0)
Intraoperative complication (n, %)		0 (0)
Postoperative and Functional Outcomes		
Hospitalization time (days) (median, IQR)		2 (2–3)
Catheterization time (days) (median, IQR)		2 (2–3)
Δ decreasing HB (g/dL) (median, IQR)		−0.60 (−0.30–0.87)
CD complications (n, %)	Early events	4 (2.3)
	• CD $\leq$ 2	4 (2.3)
	• CD $>$ 2	0 (0)
	Late events	1 (0.6)
	• CD $\leq$ 2	0 (0.0)
	• CD $>$ 2	1 (0.6)
3-mo Q_{max} (mL/s) (median, IQR)		28 (24–32)
3-mo PVR volume (mL) (median, IQR)		0 (0–10)
3-mo PSA (ng/mL) (median, IQR)		1.3 (0.9–1.8)
3-mo IPSS (median, IQR)		10 (8–11)
3-mo IIEF-5 (median, IQR)		20 (15–23)

(Continued)

TABLE 1. **Preoperative, surgical and early postoperative features of 176 patients treated with aPVP**

Preoperative characteristics	
3-mo OAB-q (median, IQR)	28 (20–33)
3-mo ICIQ-Sf (median, IQR)	0 (0–0)
3-mo QoL (median, IQR)	1 (1–2)
Stress UI at 3-mo follow-up (n, %)	0 (0)
Follow-up (month) (median, IQR)	17 (12–22)

Note. AC: Anticoagulants; AP: Antiplatelets; ASA: American Society of Anesthesiologists; BMI: Body mass index; CCI: Charlson Comorbidity Index; CD: Clavien-Dindo; Hb: Hemoglobin; ICIQ-SF: International Consultation on Incontinence Questionnaire-Short Form; IIEF-5: International Index of Erectile Function; IPSS: International Prostate Symptom Score; OAB-q: Overactive Bladder questionnaire; PVR: Post-voiding residual; UI: Urinary Incontinence; QoL: Quality of Life; Δ: Difference between 1st postoperative day and baseline value; WLR: Width-to-Length ratio; Q_{max}, max flow rate; PSA, prostate-specific antigen; TURP, transurethral resection of the prostate; mo, month; IQR, interquartile range.

TABLE 2. **Functional outcomes at 6- and 12-month assessment**

Variables	6-month evaluation	12-month evaluation
Q_{max} (mL/s) (median, IQR)	30 (27–35)	29 (24–36)
PVR volume (mL) (median, IQR)	0 (0–5)	0 (0–5)
PSA (ng/mL) (median, IQR)	1.2 (0.8–1.5)	1.1 (0.7–1.4)
IPSS (median, IQR)	8 (6–9)	7 (5–9)
IIEF-5 (median, IQR)	21 (17–24)	21 (16–24)
OAB-q (median, IQR)	22 (16–28)	20 (14–26)
ICIQ-Sf (median, IQR)	0 (0–0)	0 (0–0)
QoL (median, IQR)	1 (1–2)	1 (1–1)
Stress UI	0 (0–0)	0 (0–0)

Note. ICIQ-SF: International Consultation on Incontinence Questionnaire-Short Form; IIEF-5: International Index of Erectile Function; IPSS: International Prostate Symptom Score; OAB-q: Overactive Bladder questionnaire; PVR: Post-voiding residual; UI: Urinary Incontinence; QoL: Quality of Life; Q_{max}, max flow rate; PSA, prostate-specific antigen.

minimal median hemoglobin decrease of -0.6 g/dL. This reduction is far less than what is typically seen in other surgical modalities, reflecting the laser's capacity to manage vascular structures efficiently.

One of the distinguishing features of this study is its emphasis on a stepwise surgical approach that combines vaporization and mechanical dissection of the adenoma. This structured methodology not only enhances procedural precision but also allows for controlled modulation of energy delivery during specific phases.[27] The finding of an inverse correlation between energy delivered during early procedural steps (1–3) and improvements in storage symptoms is particularly noteworthy. This suggests that careful energy optimization during these steps can mitigate postoperative irritative symptoms, potentially reducing recovery time and enhancing patient satisfaction. The distribution of energy use revealed that step 3, focusing on capsule exposure and prostate floor treatment, required the highest median energy (median 824 kJ/mL). Proficiency in this step is crucial for optimizing outcomes while avoiding excessive energy delivery that could exacerbate postoperative symptoms.

A critical component of understanding aPVP is also identifying the factors influencing the amount of

TABLE 3. **Uni and multivariate regression model for energy delivered (>3500 kJ/mL) on the prostate**

Variable		Univariate analysis				Multivariate analysis			
		OR	*p*	95% CI		OR	*p*	95% CI	
				Lower bound	Upper bound			Lower bound	Upper bound
Body mass index (BMI, kg/m²)		1.08	0.14	0.98	1.24	–	–	–	–
PSA (continuous)		1.02	0.04	1.01	1.12	–	–	–	–
ASA score		1.14	0.02	1.03	2.41	1.16	0.76	0.86	2.97
Age-adjusted CCI score		1.25	0.02	1.11	3.11	1.22	0.57	0.75	3.14
AP/AC therapy		1.42	0.01	1.08	1.91	1.37	0.21	0.91	5.21
Preoperative prostate volume (continuous)		1.03	<0.001	1.01	1.07	1.02	0.001	1.01	1.11
WLR ratio	**High**	1.32	0.02	1.05	1.85	1.28	0.03	1.04	1.78
	Moderate	1.10	0.09	0.92	1.30	1.07	0.11	0.90	1.25
	Low	–	–	–	–	–	–	–	–

Note. AC: Anticoagulant; AP: Antiplatelet; ASA: American Society of Anesthesiologists; CCI: Charlson Comorbidity Index; WLR: width-to-length ratio; PSA, prostate-specific antigen; OR, odds ratio; CI, confidence interval.

energy delivered during the whole procedure. These predictors not only shape surgical planning and execution but also directly impact clinical outcomes, particularly postoperative recovery and symptom resolution. The study provides valuable insights into the variables that determine energy delivery, with prostate volume emerging as one of the most significant predictors. The analysis demonstrated that larger prostate volumes were strongly associated with higher energy requirements during aPVP. Multivariate regression confirmed this finding, with the prostate volume being an independent predictor of increased energy delivery (OR: 1.02, $p = 0.001$). This relationship is intuitive, as larger glands necessitate more extensive tissue vaporization and enucleation. The structured stepwise approach used in aPVP ensures that energy delivery is targeted and efficient; however, as gland size increases, the energy required to achieve complete adenoma removal correspondingly rises. The shape and dimensions of the prostate also play a critical role in determining the efficiency of laser vaporization and the total energy required for complete adenoma removal. When the prostate is wider relative to its length (high WLR), the anatomical distribution of tissue creates greater lateral bulk, which directly affects the laser application strategy. The increased width is likely to necessitate a greater overall energy output to achieve the same level of debulking as in a more elongated prostate. Additionally, in prostates with significant lateral hypertrophy, the surgical capsule may be less prominent or harder to expose. This can require longer lasing time to carefully reach and identify the anatomical boundaries, further increasing energy consumption.

The degree of prostatic tissue ablation achieved during PVP can also be indirectly estimated by monitoring postoperative PSA levels, which reflect the residual glandular volume. Lebdai et al. reported a >50% PSA reduction within one month after PVP, which remained stable for up to four years, confirming the durability of tissue ablation. Notably, PSA rebound was observed in patients receiving <3000 J/mL, while stable levels were maintained with ≥4000 J/mL.[28] Similarly, Valdivieso et al. demonstrated a dose-dependent PSA reduction after GreenLight XPS, with ≥7 kJ/mL yielding the greatest decline without increased complications .[29] This supports the role of higher energy density in ensuring durable tissue ablation. In our study, at a 3-month follow-up, we recorded a median PSA reduction of approximately 65%, which compares favorably with prior reports of PSA dynamics following GreenLight photoselective vaporization. Notably, our median energy density was lower (2447 kJ/mL), yet yielded comparable PSA suppression. This may reflect the enhanced tissue selectivity and efficiency of our anatomically guided, stepwise aPVP technique, particularly through controlled energy delivery during the initial procedural steps.

The study also explored the influence of patient comorbidities, including ASA scores and the use of AP/AC therapy. Univariate analysis showed a

significant association between higher ASA and age-adjusted CCI scores ($p = 0.02$), use of AP/AC therapy ($p = 0.01$), and increased energy delivery. However, these factors did not remain significant in multivariate analysis. The lack of an independent association in the multivariate model suggests that while these variables might indicate increased surgical complexity, they do not directly influence energy requirements. Instead, their significance in univariate analysis likely reflects the overall health status and risk profile of the patient population. Importantly, the findings highlight the adaptability of aPVP for patients on AP/AC therapy, as energy modulation ensures effective treatment without increasing perioperative risks. Another implicit factor influencing energy delivery is the surgeon's experience and proficiency with the aPVP technique.[30] While not explicitly quantified in this study, the structured nature of the five-step surgical approach suggests a direct relationship between mastery of the technique and energy efficiency. Experienced surgeons are likely better equipped to modulate energy delivery, particularly during critical phases such as steps 1 to 3, where excessive energy use is associated with postoperative irritative symptoms. Proficiency also enables surgeons to optimize the balance between vaporization and enucleation, minimizing unnecessary energy expenditure. This aspect underscores the value of comprehensive training and the need for standardized protocols to ensure consistent outcomes across surgical centers. In addition to its strong early outcomes, our study demonstrated a favorable mid-term safety profile, with a median follow-up of 17 months. During this period, the incidence of delayed complications was low, with only one patient (0.6%) developing a postoperative urethral stricture and no patients requiring surgical reintervention. These findings suggest that aPVP, when performed with a standardized approach, maintains its functional benefits over time with minimal delayed morbidity.

Despite its strength, a few limitations should be highlighted. The single-center design may have impaired the generalizability of the results. Additionally, while energy modulation appears beneficial, the underlying mechanisms warrant further investigation. While procedural outcomes in energy-based prostate surgeries are known to be influenced by surgeon experience, we minimized this bias by including only cases performed by surgeons who had already completed the learning curve for aPVP. Nonetheless, we acknowledge that in less experienced centers or during early phases of training, the learning curve may affect operative efficiency, energy delivery, and functional outcomes. Another limitation of this study is represented by the absence of a control or comparison group, such as patients undergoing TURP or holmium laser enucleation of the prostate (HoLEP). Without a direct comparator, it is not possible to definitively conclude whether the observed improvements in functional outcomes and perioperative safety are superior or equivalent to those achieved with established alternative techniques. However, while previous literature supports the efficacy and safety of GreenLight-based approaches, our study was designed as a prospective, single-arm evaluation focused on the technical aspects and functional outcomes of aPVP using a stepwise, energy-modulated approach. Lastly, while we observed a statistically significant inverse correlation between the amount of energy delivered during procedural steps 1–3 and postoperative storage symptoms, we recognize that this finding does not establish a causal relationship. Correlation alone cannot determine whether energy modulation directly influences symptom improvement, as confounding variables and unmeasured factors may have contributed to the observed association. These results should be considered hypothesis-generating and interpreted with appropriate caution. Further prospective, mechanism-focused studies are warranted to investigate the biological basis of this relationship and to determine whether targeted energy reduction strategies during specific surgical phases can meaningfully impact postoperative outcomes.

Conclusions

aPVP with the 180-W XPS GreenLight laser represents a significant advancement in the surgical treatment of BPH. By combining vaporization and enucleation in a structured, stepwise approach, this technique achieves remarkable functional outcomes while maintaining a low complication profile. Its adaptability for high-risk patients and emphasis on energy efficiency set it apart from traditional and other laser-based methods. Continued innovation and rigorous clinical evaluation will be essential in further refining this technique and expanding its adoption in modern urological practice.

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Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: Fabrizio Di Maida, Rino Oriti, Andrea Minervini; data collection: Antonio Andrea Grosso, Daniele Paganelli, Vincenzo Salamone, Sara Costagli, Francesca Solazzi, Michele Di Dio; analysis and interpretation of results: Fabrizio Di Maida, Luca Lambertini, Francesco Sessa; draft manuscript preparation: Fabrizio Di Maida, Francesca Oriti, Antonio Andrea Grosso; manuscript review and editing: Matteo Salvi, Michele Di Dio, Andrea Mari; supervision: Rino Oriti, Andrea Minervini. All authors reviewed the results and approved the final version of the manuscript.

Availability of Data and Materials

Due to the nature of this research, participants of this study did not agree to their data being shared publicly, so supporting data is not available.

Ethics Approval

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research Committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Institutional review board approval (IRB 23022/22) from Careggi University Hospital was obtained.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Conflicts of Interest

The authors declare no conflicts of interest to report regarding the present study.

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