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# Early Catheter Removal After GreenLight XPS Photovaporization in Real-World Practice: A Retrospective Cohort Study

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## Abstract

# Purpose:

To evaluate the feasibility of early catheter removal after GreenLight XPS 180W photoselective vaporization of the prostate (PVP) in a real-world setting, including outcomes in patients with prior indwelling urinary catheter (IUC) use, and to explore factors associated with catheter-free discharge.

# Methods:

This retrospective observational study included 410 consecutive patients undergoing PVP between 2018 and 2021. Patients were stratified according to prior IUC use. Continuous variables were assessed using the Shapiro–Wilk test and compared with Student's t-test or Mann–Whitney U test, while categorical variables were analyzed using chi-square or Fisher's exact test. The primary outcome was catheter-free discharge; secondary outcomes included time to catheter removal and catheter status at 30 days. Multivariable logistic regression was performed using a restricted set of clinically relevant variables.

# Results:

Sixty-four patients (15.6%) had prior catheterization. The overall catheter-free discharge rate was 90.7%, with no significant difference between previously catheterized and non-catheterized patients (85.9% vs 91.3%, p = 0.18). Time to catheter removal was slightly longer in previously catheterized patients (11.06 ± 2.40 vs 9.47 ± 2.10 hours; p = 0.12). At 30 days, catheter independence was achieved in 98.4% and 100%, respectively. No independent predictors were identified.

# Conclusions:

Early catheter removal after GreenLight XPS PVP is feasible and associated with high rates of short-term catheter independence, including in patients with prior catheterization. These findings should be interpreted with caution given the limited number of outcome events.

## INTRODUCTION

Photoselective vaporization of the prostate (PVP) using the GreenLight XPS 180W laser has become a well-established minimally invasive surgical option for the treatment of benign prostatic hyperplasia (BPH), particularly in high-volume centers and in patients with increased surgical risk [1, 2]. Compared with transurethral resection of the prostate (TURP), PVP offers comparable functional outcomes while reducing perioperative morbidity, including bleeding complications and length of hospital stay [3, 4].

Additional evidence from single-center and multicenter series has further confirmed the safety and durability of PVP outcomes across different patient populations [5–7]. Advancements in laser technology and surgical technique have expanded the indications for PVP, making it a suitable alternative even in patients receiving anticoagulation therapy or presenting with significant comorbidities [8–10]. Current international guidelines endorse laser-based techniques as standard options for the surgical management of bladder outlet obstruction secondary to BPH [11, 12].

One of the clinically relevant advantages of PVP is the potential for rapid postoperative recovery of spontaneous voiding, allowing early removal of the indwelling urinary catheter (IUC). Early catheter removal is associated with improved patient comfort, reduced risk of catheter-associated complications, and shorter hospitalization [13].

Patients requiring preoperative catheterization represent a particularly challenging subgroup. These individuals often present with more advanced bladder outlet obstruction and may have developed secondary bladder dysfunction, including detrusor underactivity [14–16]. The presence of impaired detrusor contractility has been associated with less favorable outcomes after surgical relief of obstruction in some studies [17, 18].

# METHODS

This retrospective observational cohort study included 410 consecutive patients with benign prostatic hyperplasia who underwent GreenLight XPS 180W photoselective vaporization of the prostate between January 2018 and December 2021 at a tertiary referral center. All procedures were performed by experienced surgeons using standardized surgical techniques.

Eligible patients presented with moderate-to-severe lower urinary tract symptoms refractory to medical therapy or intolerance to pharmacological treatment. Prostate volume ranged from 45 to 150 g, as assessed by imaging. Patients with suspected or confirmed prostate cancer were excluded.

Patients were stratified according to the presence or absence of a preoperative indwelling urinary catheter. Baseline variables included demographic characteristics, comorbidities, American Society of Anesthesiologists classification, prostate-specific antigen, serum creatinine, and prostate volume, as well as catheterization duration, bladder wall thickening, and post-void residual volume.

Perioperative variables included operative time, laser time, and total energy delivered. Postoperative management followed institutional protocols, with catheter removal attempted within the first postoperative day whenever clinically appropriate.

The primary outcome was catheter-free status at hospital discharge. Secondary outcomes included time to catheter removal and catheter status at 30 days postoperatively.

Preoperative urodynamic studies were not routinely performed, reflecting real-world clinical practice.

No formal sample size calculation was performed due to the observational design; all consecutive eligible patients during the study period were included.

Statistical analysis was performed using JASP software. Continuous variables were assessed for normality using the Shapiro–Wilk test and compared using Student's t-test or Mann–Whitney U test, as appropriate. Categorical variables were analyzed using chi-square or Fisher's exact test.

Given the limited number of outcome events, multivariable logistic regression analysis was performed using a restricted set of clinically relevant variables—prior catheterization, bladder wall thickening, prostate volume, and laser time—to minimize overfitting in accordance with recommended events-per-variable principles. Continuous predictors were modeled per clinically meaningful increments (per 10 g increase in prostate volume and per 10 min increase in laser time). Results are reported as odds ratios with 95% confidence intervals.

Missing data were minimal (< 5% for all variables) and were handled using complete-case analysis without imputation.

No sensitivity analyses were performed.

A two-sided p-value < 0.05 was considered statistically significant.

The study was conducted in accordance with the STROBE guidelines and approved by the institutional review board. The requirement for informed consent was waived due to the retrospective design.

# RESULTS

A total of 410 patients were included, of whom 64 (15.6%) had a prior indwelling urinary catheter. Baseline characteristics are summarized in Table 1. Patients with prior catheterization were older and had larger prostate volumes, suggesting more advanced disease.

Table 1
Baseline clinical and preoperative characteristics according to preoperative indwelling urinary catheter (IUC) status

| Variable | Preoperative IUC (n = 64) | No preoperative IUC (n = 346) | p-value |
|---|---|---|---|
| *Demographics* | | | |
| Age (years), mean ± SD | 74.1 ± 8.1 | 70.8 ± 7.9 | 0.010 |
| BMI (kg/m²), mean ± SD | 26.8 ± 4.5 | 27.2 ± 4.8 | 0.412 |
| *Comorbidities and surgical risk* | | | |
| ASA class II, n (%) | 59 (92.2) | 309 (89.3) | 0.548 |
| ASA class III, n (%) | 5 (7.8) | 37 (10.7) | —* |
| Hypertension, n (%) | 48 (75.0) | 220 (63.6) | 0.246 |
| Diabetes mellitus, n (%) | 20 (31.3) | 114 (32.9) | 0.930 |
| Current or former smoking, n (%) | 5 (7.8) | 21 (6.1) | 0.683 |
| Prior stroke, n (%) | 2 (3.1) | 16 (4.6) | 1.000 |
| *Medications* | | | |
| Aspirin use, n (%) | 15 (23.4) | 80 (23.1) | 0.853 |
| Preoperative laboratory data | | | |
| PSA (ng/mL), median (IQR) | 4.13 (2.1–8.7) | 2.83 (1.5–6.2) | 0.300 |
| Creatinine (mg/dL), mean ± SD | 1.19 ± 0.42 | 1.07 ± 0.38 | 0.104 |
| *Preoperative imaging* | | | |
| Prostate volume (g), median (IQR) | 80.3 (60–110) | 66.3 (50–90) | 0.001 |

Abbreviations: BMI, body mass index; ASA, American Society of Anesthesiologists; PSA, prostate-specific antigen; IUC, indwelling urinary catheter; IQR, interquartile range; SD, standard deviation.

*p-value not calculated for ASA subcategories as part of the same categorical variable.

Overall, 372 patients (90.7%) were discharged without a catheter (Table 2). No significant differences were observed between patients discharged with or without a catheter regarding baseline or intraoperative variables.

**Table 2. Clinical and perioperative factors according to catheter status at hospital discharge**

| Variable | Discharge without IUC (n = 372) | Discharge with IUC (n = 38) | p-value |
|---|---|---|---|
| *Preoperative factors* | | | |
| Prior catheterization, n (%) | 58 (15.6) | 6 (15.8) | 0.848 |
| Bladder wall thickening, n (%) | 166 (44.5) | 18 (47.4) | 0.975 |
| Catheterization duration (months), mean ± SD | 0.72 ± 2.18 | 0.67 ± 1.81 | 0.862 |
| Prostate volume (g), median (IQR) | 68.9 (50–90) | 65.7 (45–88) | 0.507 |
| Post-void residual (mL), mean ± SD | 92.3 ± 146.8 | 75.7 ± 124.2 | 0.441 |
| *Intraoperative factors* | | | |
| Operative time (min), mean ± SD | 67.5 ± 29.6 | 74.3 ± 28.0 | 0.155 |
| Laser time (min), mean ± SD | 35.2 ± 16.5 | 39.4 ± 14.6 | 0.096 |
| Energy delivered (kJ), mean ± SD | 314.7 ± 217.4 | 342.1 ± 143.3 | 0.288 |

Data are presented as mean ± standard deviation or median (interquartile range) unless otherwise indicated.

IUC: indwelling urinary catheter.

Comparisons were performed using Student’s t-test or Mann–Whitney U test for continuous variables and chi-square or Fisher’s exact test for categorical variables.

Catheter-free discharge rates were 85.9% in previously catheterized patients and 91.3% in those without prior catheterization (p=0.18). Time to catheter removal was slightly longer in the prior catheterization group but did not reach statistical significance.

At 30 days, catheter independence was nearly universal (98.4% vs 100%), indicating excellent short-term recovery (Table 3). Despite baseline differences, outcomes remained consistently favorable across subgroups.

**Table 3. Postoperative outcomes according to prior indwelling urinary catheter (IUC) use**

| Variable | Prior IUC (n = 64) | No prior IUC (n = 346) | p-value |
|---|---|---|---|
| *Preoperative variable* | | | |
| Catheterization duration (months), mean ± SD | 4.33 ± 3.10 | — | — |
| *Postoperative outcomes* | | | |
| Catheter-free discharge, n (%) | 55 (85.9) | 316 (91.3) | 0.18 |
| Time to catheter removal (hours), mean ± SD | 11.06 ± 2.40 | 9.47 ± 2.10 | 0.12 |
| Catheter-free at 30 days, n (%) | 63 (98.4) | 346 (100) | 1.000 |

Data are presented as mean ± standard deviation unless otherwise indicated.

IUC: indwelling urinary catheter.

Multivariable analysis did not identify independent predictors of catheter-free discharge (Table 4). When modeled per clinically meaningful increments, neither prostate volume (per 10 g increase) nor laser time (per 10-minute increase) was significantly associated with the outcome. Wide confidence intervals reflected limited precision due to the small number of failure events. These findings are illustrated in Figure 1.

**Table 4. Multivariable logistic regression analysis for predictors of catheter-free discharge**

| Variable | OR | 95% CI | p-value |
|---|---|---|---|
| Prior catheterization (yes vs no) | 0.98 | 0.42–2.31 | 0.960 |
| Bladder wall thickening (yes vs no) | 0.91 | 0.45–1.83 | 0.780 |
| Prostate volume (per 10 g increase) | 0.90 | 0.82–1.00 | 0.180 |
| Laser time (per 10 min increase) | 0.74 | 0.54–1.10 | 0.110 |

OR: odds ratio; CI: confidence interval.

Continuous variables were rescaled (per 10 g and per 10 minutes) to improve clinical interpretability.

Variables were selected based on clinical relevance to minimize overfitting given the limited number of outcome events.

# DISCUSSION

This study demonstrates that early catheter removal after GreenLight XPS photoselective vaporization of the prostate is feasible in a real-world setting, including in patients with prior indwelling urinary catheter

use. The high overall rate of catheter-free discharge supports the ability of PVP to promote early recovery of spontaneous voiding, even among patients traditionally considered at higher risk, in line with previous reports demonstrating rapid functional recovery following laser-based therapies [9–12].

Although patients with prior catheterization showed numerically lower catheter-free rates at discharge, no statistically significant differences were observed between groups. These findings should be interpreted with caution, as the relatively small number of failure events limits statistical power to detect modest but clinically relevant differences. Furthermore, the near-universal catheter independence observed at 30 days suggests a ceiling effect, which may further obscure potential differences between subgroups.

Patients requiring preoperative catheterization often represent a more complex clinical population, characterized by prolonged bladder outlet obstruction and a higher likelihood of detrusor underactivity. While impaired detrusor contractility has been associated with less favorable postoperative outcomes in some studies [17,18], more recent evidence suggests that meaningful functional recovery remains achievable following adequate relief of obstruction. The present findings are consistent with this evolving perspective, as most previously catheterized patients achieved early catheter removal and near-complete catheter independence at short-term follow-up.

A notable aspect of this study is the absence of routine preoperative urodynamic evaluation. Although urodynamic testing may provide valuable functional insights, its role in routine clinical decision-making remains debated. In this cohort, the omission of systematic urodynamic assessment reflects a pragmatic, real-world approach. The high rates of catheter independence observed suggest that satisfactory short-term outcomes can be achieved without routine urodynamic testing in patients with clear clinical and imaging evidence of bladder outlet obstruction. Nonetheless, selective use of urodynamics may still be warranted in cases of diagnostic uncertainty, as supported by prior literature on bladder dysfunction [19–21].

From a methodological standpoint, no independent predictors of catheter-free discharge were identified. When continuous variables were modeled using clinically interpretable increments (per 10 g increase in prostate volume and per 10-minute increase in laser time), effect estimates remained small and statistically non-significant. These findings likely reflect both the limited number of outcome events and the absence of strong predictors in this cohort. The wide confidence intervals observed in the regression analysis further highlight the limited precision of the estimates and the possibility of a type II error. Additionally, residual confounding cannot be excluded, particularly given baseline differences in age and prostate volume between groups.

Future studies using more robust analytical approaches, such as propensity score matching or penalized regression techniques, may help to better characterize predictors of early catheter removal. In addition, incorporation of standardized functional outcomes, including symptom scores and uroflowmetry parameters, would provide a more comprehensive assessment of postoperative recovery.

This study has several limitations, including its retrospective design, potential selection bias inherent to a single high-volume center, and the lack of standardized functional outcome measures. The relatively short follow-up period also precludes assessment of long-term durability. However, the inclusion of a large consecutive cohort and the focus on real-world clinical practice strengthen the external validity of the findings.

Despite these limitations, the present study provides clinically relevant evidence supporting the feasibility of early catheter removal after GreenLight XPS PVP. These results contribute to the ongoing discussion regarding perioperative management strategies and patient selection, particularly in higher-risk populations, and further support the role of laser-based therapies as a standard surgical option for benign prostatic hyperplasia [1–4,11].

# CONCLUSIONS

Early catheter removal after GreenLight XPS photovaporization is feasible and associated with high rates of short-term catheter independence in real-world practice, including in patients with prior catheterization.

Although no statistically significant differences were observed, these findings should be interpreted cautiously given the observational design and limited statistical power.

These results support the applicability of early catheter removal strategies in a broad patient population. Further prospective studies are warranted.

# Declarations

### CONFLICT OF INTEREST

The authors declare that they have no conflict of interest related to this study.


### FINANCIAL SUPPORT

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### ETHICAL REVIEW STATEMENT

Ethical approval for this study was obtained from Plataforma Brasil (CAAE:90373025.0.0000.8114)

### DATA AVAILABILITY

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

### AUTHOR CONTRIBUTIONS

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by the authors. All authors read and approved the final manuscript.

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# Figures

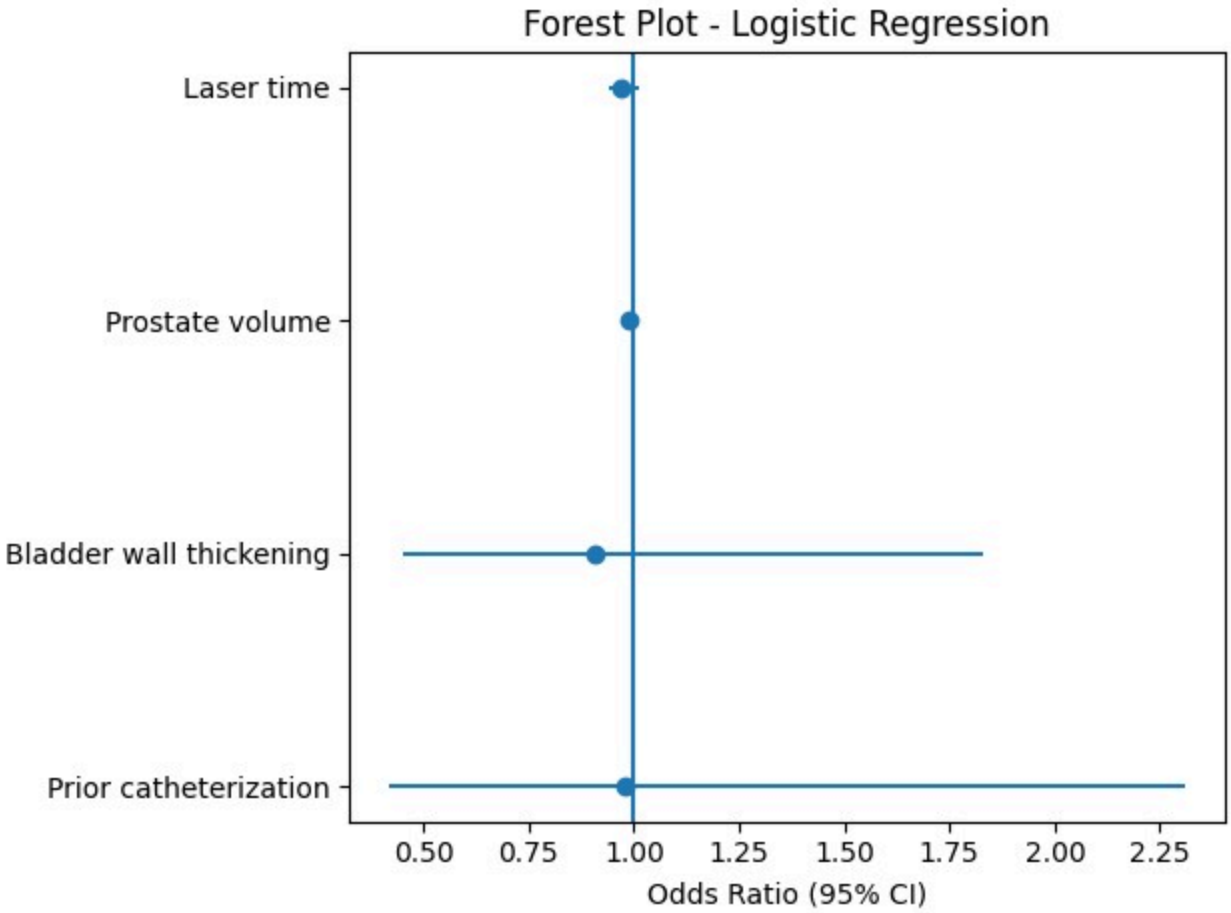



**Figure 1**

**Forest plot of multivariable predictors of catheter-free discharge.**

Odds ratios (ORs) with 95% confidence intervals (CIs) are presented for variables included in the multivariable logistic regression model. Continuous variables were scaled per clinically meaningful increments (per 10 g increase in prostate volume and per 10-minute increase in laser time). No variable was significantly associated with catheter-free discharge.
CI confidence interval, OR odds ratio.