

# Cost analysis of Greenlight photoselective vaporization of the prostate compared to transurethral resection of the prostate for benign prostatic hyperplasia

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## Abstract

**Introduction:** Benign prostatic hyperplasia (BPH) is a non-cancerous enlargement of the prostate gland, which results in the development of lower urinary tract symptoms that can interfere with patients' daily activities and negatively impact their quality of life. The gold standard treatment for moderate to severe BPH has been transurethral resection of the prostate (TURP), however, this procedure is associated with prolonged hospitalizations and increased complications. An alternative to TURP is Greenlight photoselective vaporization of the prostate (PVP), which is associated with better perioperative safety. The objectives of the research were to: 1) assess the cost of Greenlight PVP compared to TURP and bipolar TURP; and 2) assess the predictors of total cost.

**Methods:** We conducted a descriptive costing study from the hospital perspective. We evaluated perioperative costs of patients who underwent each procedure from 2013–2015 at a tertiary academic medical centre. A multiple linear regression was performed to identify predictors of total cost. The variables included in regression analysis were patient age, type of procedure, Charlson Comorbidity Index, and distance to clinic.

**Results:** A total of 202 patients received one of the three procedures over the study period. The total cost of Greenlight PVP was \$3836 per patient compared to \$4963 for TURP and \$4978 for bipolar TURP. The linear regression showed that the Charlson Comorbidity Index and type of procedure were independent predictors of total cost.

**Conclusions:** The procedure costs and readmission rates are lower for Greenlight PVP compared to TURP and bipolar TURP, making it a preferable option for hospitals.

## Introduction

Benign prostatic hyperplasia (BPH) is a non-cancerous enlargement of the prostate gland, which results in the development of lower urinary tract symptoms (LUTS) that can interfere with patients' daily activities and negatively impact their quality of life.<sup>1</sup> BPH affects up to 50% of men aged 50 years and older, with symptoms increasing with age.<sup>2</sup>

The gold standard surgical treatment for moderate to severe BPH has been transurethral resection of the prostate (TURP). During this procedure, the physician inserts a scope into the urethra and uses an electrified wire loop to cut the prostate tissue. A newer form of this procedure, using bipolar electricity, called bipolar plasma vaporization of the prostate, uses low-temperature plasma energy to remove the prostate tissue. The main device used for this modality is the Olympus Plasma Button (Olympus Corporation, Tokyo, Japan). TURP, however, has been associated with prolonged hospitalization and increased rates of complications.<sup>3</sup> These complications include blood transfusion and TURP syndrome. An alternative to TURP is photoselective vaporization of the prostate (PVP) with Greenlight laser (Boston Scientific, Marlborough, U.S.). Greenlight PVP is an outpatient procedure that has better perioperative safety, shorter hospitalization time, faster symptomatic improvement, and decreased morbidity compared to TURP.<sup>4,5</sup>

Studies have compared the cost of TURP to Greenlight PVP<sup>6-10</sup> and have consistently found that Greenlight PVP is less costly. These cost savings have been mainly due to patients being treated on an outpatient bases with Greenlight PVP. Only one cost analysis has found that Greenlight PVP is more costly than TURP.<sup>11</sup> This study was from Australia and reported that Greenlight PVP costs \$79 (AUD) more than TURP per patient.<sup>11</sup> This was due to the cost of equipment and training.<sup>11</sup> When these costs were excluded from the analysis, Greenlight PVP was cost-saving compared to TURP.

Two studies in Canada have compared the costs associated with Greenlight PVP to TURP.<sup>10</sup> One study was a prospective, non-randomized trial that followed patients up to six months following surgery.<sup>10</sup> The study found that due to the outpatient nature of Greenlight PVP, treating subjects with Greenlight PVP instead of TURP decreased the total costs by almost \$1300 (CAD) per patient. The other Canadian study was a cost-minimization analysis from the payer's perspective. This study found that PVP cost less than TURP even after accounting for startup costs.<sup>6</sup> Many hospitals and healthcare payers continue to modernize their BPH surgical equipment, and considerations of cost should be taken into account.

The objective of our study was to compare the costs of Greenlight PVP vs. TURP and bipolar TURP from a hospital perspective, as well as to determine the predictors of total cost.

## Methods

### Patient population

A retrospective analysis was conducted of perioperative hospital costs of patients who underwent Greenlight PVP, TURP, or bipolar TURP. Costs were based on surgeries conducted between September 2013 and September 30, 2015 at the Toronto Western Hospital, Toronto, Ontario.

The XPS Greenlight 180W system was used by all physicians. Greenlight PVP procedures were performed by three physicians trained to use the laser system. For this analysis, the first 10 cases of Greenlight PVP for each physician were excluded from the analysis due to the learning curve of using the new technology. In addition, patients presenting through the emergency department were also excluded.

### Chart review and administrative databases

Data on patient age, Charlson Comorbidity Index, number of patients on anticoagulation therapy, patients on past medical therapy for BPH, and number of patients with a diagnosis of prostate cancer were captured through chart review. Distance to clinic was captured using patient postal codes from chart reviews. The type of procedure, length of stay, procedure costs, and the number of readmissions at 30 and 60 days post-intervention were obtained from the Toronto Western Hospital administrative database.

### Cost analysis

Costs were captured from the perspective of the hospital. For each patient, both direct and indirect hospital costs were obtained for each procedure. Variable direct costs included the cost of labour (medical personnel on fee for

service), patient supplies, and drugs. The cost of the fibre for Greenlight PVP, resecting loop for TURP, and the Olympus plasma button, as well as drug costs were included in the variable patient supply cost. Fixed direct costs included the cost of labour (medical personnel not paid through fee for service), equipment, building, and grounds. Variable and fixed indirect costs pertained to hospital operating costs (i.e., functional centre costs classified as overhead). A cost per patient was calculated by dividing the total costs by the number of patients in each group. All costs are reported in 2015 Canadian dollars.

### Statistical analysis

Data were captured in Excel® 2011 and statistical analysis was conducted in STATA 14.1. Mean costs and the 95% confidence intervals (CI) are presented. Multiple linear regression analysis was performed in order to identify predictors of total cost and obtain covariate-adjusted costs. The total cost included the cost of the procedure and readmissions at 60 days. The variables included in the regression analysis were the type of procedure, patient age, Charlson Comorbidity Index, and distance to the clinic. For type of procedure, Greenlight PVP was used as the reference category. Age and distance to the clinic were continuous variables.

## Results

### Patient characteristics

A total of 222 patients received a procedure for BPH from 2013–2015. After exclusion of the first 10 cases of Greenlight PVP for each physician, 202 patients corresponding to 203 visits involving Greenlight PVP (n=56), bipolar TURP (n=29), and TURP (n=118) were included in the analysis. No deaths were reported during the study period.

The general characteristics of patients and hospital data are presented in Table 1. On average, patients were 71 years of age and approximately 90% had a previous history of BPH therapy. These characteristics were similar across all treatment groups. Overall, more patients undergoing Greenlight PVP (27%) were on anticoagulation therapy vs. bipolar TURP (24%) and TURP (15%). The number that had retention at the time of surgery and the number that had a previous TURP were comparable across groups.

Substantially more patients were treated on an outpatient basis with Greenlight PVP (93%) vs. bipolar TURP (0%) and TURP (6%). On average, the inpatient length of stay was shorter for Greenlight PVP compared to TURP and bipolar TURP (1.03 vs. 1.67 days and 1.45, respectively). The mean operating room times were one hour and 30 minutes for Greenlight PVP, one hour and 18 minutes for TURP, and

**Table 1. Patient characteristics and hospital data (n=203)**

Variable	Greenlight PVP (n=56)	Bipolar TURP (n=29)	TURP (n=118)
Age, years (SD)	72 (10)	71 (9)	71 (8)
Patients on anticoagulation therapy, n (%)	15 (27)	7 (24)	18 (15)
Patients with past medical therapy for BPH, n (%)	49 (88)	26 (90)	105 (89)
Prostate cancer, n (%)	5 (9)	0 (0)	8 (7)
Median lobe, n (%)	35 (62%)	54 (46%)	11 (38%)
Retention at time of surgery, n (%)	21 (37%)	42 (36%)	12 (41%)
Previous TURP, n (%)	6 (11%)	21 (18%)	5 (17%)
Charlson Comorbidity Index	0.86 (1.24)	0.93 (1.75)	0.95 (1.33)
No visits, n (%)			
Procedure completed as an outpatient	52 (93%)	0 (0%)	7 (6%)
Procedure completed as an inpatient	4 (7%)	29 (100%)	111 (94%)
Inpatient length of stay, days	1.03 (0.27)	1.45 (0.57)	1.67 (0.56)
Distance to clinic, km	18.81 (27.87)	11.11 (10.21)	28.10 (92.73)
OR time in hours, mean (SD)	1.30 (0.54)	1.18 (0.38)	1.09 (0.40)
Number of laser fibre			
Laser fibre=1 N (%)	55 (98%)	0	0
Laser fibre=2 N (%)	1 (2%)	0	0

Data are presented as mean (SD) unless otherwise indicated. BPH: benign prostatic hyperplasia; OR: operating room; PVP: photoselective vaporization of the prostate; SD: standard deviation; TURP: transurethral resection of the prostate.

one hour and 9 minutes for bipolar TURP. The majority of patients who underwent Greenlight PVP had one laser fibre used for the procedure (98%).

### Total costs

Table 2 reports the mean per-patient cost for all cases (i.e., including both day surgery and inpatient cases) by type of procedure. In total, Greenlight PVP cost \$3836, bipolar TURP \$4978, and TURP \$4963 per patient. Greenlight PVP was the least costly option, costing on average \$1127 less than TURP and \$1142 less than bipolar TURP.

### Cost of day surgery and inpatient cases

With respect to type of procedure, 93% of Greenlight PVP procedures were performed as day surgery, in contrast to approximately 6% of TURP and none of the bipolar TURP procedures (Table 1). Therefore, savings in overall cost are mainly attributed to a reduced frequency of costlier inpatient hospitalizations with Greenlight PVP vs. other procedures.

Tables 3 and 4 report the mean costs per patient for day surgery and inpatient cases, respectively, by type of procedure. For day surgery cases, there were 52 cases for Greenlight PVP and seven cases for TURP. Out of the seven TURP cases, three patients were undergoing revisions of a prior TURP procedure. Greenlight PVP cost \$3713 and TURP cost \$2672 per patient. On average, Greenlight PVP cost \$1041 more than TURP for day surgery cases. This cost difference is mainly attributed to increased variable labour and patient supply cost for Greenlight PVP.

For inpatient cases (Table 4), on average, Greenlight PVP cost \$5432, bipolar TURP \$4978 and TURP \$5109 per patient. Thus, for inpatient cases, Greenlight PVP cost \$344 more than TURP and \$475 more than bipolar TURP.

### Readmissions

Greenlight PVP resulted in lower hospital readmission rates at 30 and 60 days compared to TURP (14% vs. 19%, and

**Table 2. Mean total cost per patient per procedure for both inpatient and day surgery cases (n=203)**

Variable	Mean (95% CI) (\$)			Difference in cost*	
	Greenlight PVP n=56	Bipolar TURP n=29	TURP n=118	Greenlight vs. TUR	Greenlight vs. bipolar TURP
Variable direct					
Labour	847 (722–922)	1767 (1492–2041)	1651 (1536–1766)	(804)	(920)
Patient supplies	1,600 (1456–1744)	1093 (888–1299)	1098 (1030–1166)	502	507
Other	1 (0.35–3.08)	11 (8.75–14.17)	10 (9–12)	(9)	(10)
Fixed direct					
Labour	145 (128–162)	319 (269–370)	319 (297–341)	(174)	(174)
Other	147 (130–165)	194 (168–220)	209 (198–220)	(62)	(47)
Variable indirect	720 (655–785)	1108 (957–1259)	1125 (1061–1188)	(405)	(388)
Fixed indirect	376 (335–418)	486 (423–549)	551 (524–579)	(175)	(110)
Total cost	3836 (3538–4137)	4978 (4321–5637)	4963 (4701–5226)	(1127)	(1142)

\*Brackets indicate that Greenlight is less costly. Costs do not include cost of readmission. Variable direct: cost of labour (medical personnel on fee for service), patient supplies, and drugs; fixed direct cost of labour (medical personnel not paid through fee for service) and equipment, building and grounds; variable and fixed indirect: hospital operating costs (i.e., functional centre costs classified as overhead). CI: confidence interval; PVP: photoselective vaporization of the prostate; TURP: transurethral resection of the prostate.

**Table 3. Mean cost per patient per procedure for day surgery cases only**

Variable	Mean Costs (95% CI) (\$)		Difference in cost*
	Greenlight PVP n=52	TURP n=7	
Variable direct			
Labour	803 (740–866)	510 (339–681)	293
Patient supplies	1583 (1429–1737)	997 (654–1339)	586
Other	0.24 (0.11–0.36)	0.25 (0.18–0.68)	(0.01)
Fixed direct			
Labour	133 (122–144)	82 (40–125)	51
Other	141 (124–158)	140 (93–185)	2
Variable indirect	691 (631–752)	600 (432–769)	91
Fixed indirect	362 (324–400)	343 (236–451)	19
Total cost	3713 (3420–4006)	2672 (1776–3568)	1041

\*Brackets indicate Greenlight is less costly. Costs do not include cost of readmission. Variable direct: cost of labour (medical personnel on fee for service), patient supplies, and drugs; fixed direct cost of labour (medical personnel not paid through fee for service) and equipment, building and grounds; variable and fixed indirect: hospital operating costs (i.e., functional centre costs classified as overhead). CI: confidence interval; PVP: photoselective vaporization of the prostate; TURP: transurethral resection of the prostate.

0% vs. 4%, respectively) (Table 5). There were also lower readmission rates at 30 days compared to bipolar TURP (14% vs. 28%). The mean readmission cost per patient at 30 days was lower for Greenlight PVP vs. TURP. At 60 days, there were no readmissions for Greenlight PVP, no readmissions for bipolar TURP, and four readmissions for TURP. The mean per-patient cost of readmissions at 60 days for TURP was \$2460.

### Predictors of total costs

Table 6 reports the results of the multiple linear regression analysis of total costs adjusting for the type of procedure, patient age, comorbidity, and distance from clinic. Based on

the regression analysis, the type of procedure and Charlson Comorbidity Index were independent predictors of total costs (p<0.01). After adjusting for covariates, Greenlight PVP was associated with a decrease in costs of \$1219 vs. TURP and \$1156 vs. bipolar TURP. As well, after adjustment for covariates, those with a Charlson Comorbidity Index of 2 or more had a \$769 increase in costs.

### Discussion

TURP has been the established gold standard procedure for BPH. Decisions regarding the introduction of a new technology, such as Greenlight PVP, often involve considerations of safety, value for money, patient values, and feasibility of adoption into the healthcare system.

In regards to patient safety, Greenlight PVP is a painless procedure that can be offered in an outpatient setting. Three literature reviews on the safety profiles of the two technologies found that adverse events (i.e., urinary retention and clot retention) were comparable or lower for Greenlight PVP compared to TURP.<sup>6,12,13</sup> Our study found that readmissions to hospital after Greenlight PVP were less than that of TURP. TURP resulted in 15 more readmissions at 30 days and four more readmissions at 60 days. However, others have found that readmissions between the two treatments are comparable.<sup>6,10</sup> One Canadian study has reported no readmissions and three readmissions for Greenlight PVP over a six-month period.<sup>10</sup> For Greenlight PVP compared to bipolar TURP, the number of readmission at 30 and 60 days were comparable.

It has also been reported that there is no difference in health-related quality of life between Greenlight PVP and TURP.<sup>10,13</sup> There are some discrepancies within the literature as to whether there is greater preservation of sexual function with Greenlight PVP compared to TURP. Although some have reported there is no difference in sexual function between Greenlight PVP and TURP,<sup>5,10,14</sup> others have

**Table 4. Mean cost per patient per procedure for inpatient cases only**

Variable	Mean (95% CI) (\$)			Difference in cost*	
	Greenlight PVP n=4	Bipolar TURP n=29	TURP n=111	Greenlight vs. TURP	Greenlight vs. bipolar TURP
Variable direct					
Labour	1425 (1055–1796)	1767 (1491–2042)	1723 (1614–1832)	(298)	(342)
Patient supplies	1824 (1699–1949)	1093 (888–1299)	1104 (1034–1174)	720	731
Other	16 (5–37)	11 (9–14)	11 (10–13)	5	5
Fixed direct					
Labour	299 (162–436)	319 (269–370)	334 (314–354)	(35)	(20)
Other	233 (142–324)	194 (157–220)	213 (202–224)	20	39
Variable indirect	1094 (779–1408)	1108 (957–1259)	1158 (1096–1220)	(64)	(15)
Fixed indirect	562 (287–838)	486 (423–549)	566 (538–592)	(2)	76
Total cost	5453 (4512–6395)	4978 (4321–5637)	5109 (4856–5360)	344	475

\*Brackets indicate Greenlight is less costly. Costs do not include cost of readmission. Variable direct: cost of labour (medical personnel on fee for service), patient supplies, and drugs; fixed direct cost of labor (medical personnel not paid through fee for service) and equipment, building and grounds; variable and fixed indirect: hospital operating costs (i.e., functional centre costs classified as overhead). CI: confidence interval; PVP: photoselective vaporization of the prostate; SD: standard deviation; TURP: transurethral resection of the prostate.



**Table 5. Readmission costs at 30 and 60 days**

Variable	Greenlight PVP	Bipolar TURP	TURP
Total readmissions, n (%)	8 (14)	8 (28)	27 (23)
Readmission at 30 days, n (%)	8 (14)	8 (28)	23 (19)
Total cost of readmission at 30 days, mean (SD)	\$359 (\$236)	\$225 (\$96)	\$383 (\$419)
Readmission at 60 days, n (%)	0 (0)	0 (0)	4 (4)
Total cost of readmission at 60 days, mean (SD)	0	0	\$2460 (\$3811)

PVP: photoselective vaporization of the prostate; SD: standard deviation; TURP: transurethral resection of the prostate.

reported there is a significantly lower retrograde ejaculation rate among those who received Greenlight PVP.<sup>15</sup>

Given comparable patient safety and quality of life outcomes for both treatments, whether Greenlight PVP should be adopted as an alternative to TURP may be a matter of cost. We found that Greenlight PVP cost \$1142 less than bipolar TURP and \$1127 less than TURP. The savings in costs are mainly attributed to costly inpatient hospitalizations associated with TURP. These results are consistent with a Canadian study that reported Greenlight PVP cost \$1300 less per patient in comparison to TURP.<sup>10</sup> Our study results are also similar to other studies that have found Greenlight PVP to be less costly than TURP.<sup>6,7,10,11</sup> The reason for these findings has been that Greenlight PVP is provided on an outpatient basis and TURP requires inpatient postoperative care. While the bipolar TURP may be performed as outpatient surgery in certain highly selected patients, this has not been the case at our institution.

In addition to a cost analysis, we also conducted a multiple linear regression to determine the predictors of total cost. We found that both the type of procedure and the Charlson Comorbidity Index were statistically significant predictors of total cost. Consistent with our costing results, Greenlight PVP was associated with lower costs compared to bipolar TURP and TURP. Those with a Charlson Comorbidity Index of 2 or greater had higher costs than those with a lower index. It could be that the comorbidities are associated with a greater length of stay in hospital or require more resources.

There are some strengths and limitations of this study that should be noted. First, this analysis was conducted from a hospital perspective and so costs incurred by the Ministry of Health and Long-Term Care, as well as patient out-of-pocket costs were not included. Second, we did not include costs associated with followup procedures; however, our analysis provides insight into the perioperative hospital costs and readmissions at 30 and 60 days. Third, this was a single-institution study and so the results may not be generalizable to other settings. Lastly, we examined cases at the introduction of Greenlight PVP and so there may be a learning curve among physicians in terms of performing the procedure. As a result,

**Table 6. Predictors of total cost (initial procedure + readmissions)**

Variable	Coefficient (95% CI)	p
Procedure vs. Greenlight PVP (reference)		
TURP	1219 (732, 1707)	<0.01
Bipolar TURP	1156 (170, 1843)	0.01
Age	-11.73 (-37, 13)	0.360
Charlson Comorbidity Index >2	769 (93, 1445)	0.026
Distance to clinic, km	0.36 (-2.59, 3.31)	0.812

CI: confidence interval; PVP: photoselective vaporization of the prostate; TURP: transurethral resection of the prostate.

we decided to exclude the first 10 cases of Greenlight PVP for each physician. Despite these limitations, we believe that this study contributes to improving our estimates of the marginal costs of Greenlight PVP and essential clinical policy-making.

## Conclusion

Greenlight PVP appears to be a safe and economically attractive option when compared to bipolar TURP and TURP. The procedure costs and readmission rates are lower for Greenlight PVP, making it a preferable option for the hospital.

**Competing interests:** The authors report no competing personal or financial interests.

This paper has been peer-reviewed.

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