

Surgical management of benign prostatic obstruction: 20-year population-level trends

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Abstract

Introduction: Benign prostatic obstruction (BPO) due to histological benign prostatic hyperplasia is highly prevalent among older men. Despite widespread use of medical therapy, surgical treatment remains a mainstay in the management of BPO. We sought to characterize trends in the surgical management of BPO in Ontario, Canada.

Methods: We performed an interrupted time-series analysis using segmented regression among men aged 18 years and older undergoing surgical treatment for BPO between January 1, 1994 and December 31, 2014 in Ontario, Canada. The passage of time was considered the primary exposure. The primary outcome was the proportion of all BPO surgeries performed using each of the following modalities: transurethral resection of the prostate (TURP), endoscopic laser prostatectomy, open/laparoscopic prostatectomy, and others.

Results: We identified 136 459 men who underwent BPO surgery between 1994 and 2014. The annual age-adjusted rate of BPO surgery declined significantly over time (24 to 10 per 10 000 population in 1994 and 2014, respectively). From 1994–2001, there were no significant changes in the distribution of BPO surgical modalities, with TURP the most common throughout (97.2% and 97% in 1994 and 2001, respectively). From 2002–2014, there was a significant decline in the use of TURP (92.1% to 76.9%; $p=0.027$) with a corresponding increase in the use of endoscopic laser prostatectomy (3.5% to 21.9%; $p=0.0008$).

Conclusions: This study demonstrates a shift in the management of BPO, with increasing use of endoscopic laser prostatectomy, beginning in 2002. However, TURP remains the most common treatment modality.

Introduction

Benign prostatic obstruction (BPO) due to histological benign prostatic hyperplasia contributes to significant lower urinary tract symptoms among aging men. By the seventh decade of life, such voiding symptoms affect nearly 75% of men.^{1,2} Historically, surgical treatment, either transurethral resection of the prostate (TURP) or simple open prostatectomy, was the treatment of choice. Since the early 1990s, medical therapy for BPO has been indicated as first-line treatment for men with moderate to severe symptoms.^{3,4} However, surgical treatment remains the standard of care among patients for whom medical therapy is ineffective, who are unwilling to try medical therapy, and those with complications due to BPO.³ While TURP remains the gold standard therapy,³ recent data have shown that endoscopic laser prostatectomy (photovaporization and enucleation) may confer similar outcomes with lower rates of complications^{5,6} and overall costs.⁷

We sought to assess trends in the surgical management of BPO using population-level data from the province of Ontario, a jurisdiction with a single-payer healthcare system capturing a population in excess of 13 million.

Methods

We conducted a retrospective cohort study of men undergoing surgical management of BPO in the province of Ontario between January 1, 1994 and December 31, 2014. In Ontario, medical care is reimbursed by a single, government-funded health insurance system (Ontario Health Insurance Plan [OHIP]), which finances both inpatient and outpatient care. We used Canadian Classification of Health Intervention (CCI) codes to identify patients in the Canadian Institute of Health Information (CIHI) Discharge Abstract Database and National Ambulatory Care Reporting System databases, both of which are validated data sources.⁸ Using CCI codes, we categorized patients as having received TURP,

endoscopic laser prostatectomy, open/laparoscopic prostatectomy, or other BPO procedures (including microwave, radiofrequency, or ultrasound endoscopic destruction of the prostate). We excluded patients coded as female, those under the age of 18 at the time of surgery, and those with a history of prostate cancer prior to surgery. We considered only the first BPO surgery during the time interval.

This study was approved by the Sunnybrook Health Sciences Centre Research Ethics Board.

Outcomes

We first examined the two- and five-year cumulative incidence of BPO surgery in men, stratified by age categories, to examine for overall trends in the rates of these procedures.

Second, as our primary outcome, we examined trends in the use of particularly surgical approaches, namely TURP, endoscopic laser prostatectomy, open/laparoscopic prostatectomy, and other BPO procedures, over time. We measured these as a proportion of all BPO treatments.

Finally, we examined trends in the patient characteristics at the time of BPO surgery over time. We assessed comorbidity using the Johns Hopkins resource utilization band (RUB) score and operationalized this as a categorical variable. Age was operationalized both by calculating the mean age and by categorizing it (age <50 years, 50–60 years, 60–70 years, 70–80 years, and >80 years).

Statistical analysis

First, we calculated the two- and five-year cumulative incidence of requiring a BPO surgical intervention, stratified by age group (<50, 50–59, 60–69, 70–79, >80 years old). We examined the entire population of Ontario and calculated the cumulative incidence of intervention per 1000 population for men who were in each age group as of 1995, as of 2000, as of 2005, and as of 2010 using the Kaplan-Meier method in order to identify changes over time. We quantified trends in the cumulative incidence of BPO surgery over time using the Cochran-Armitage test for trend.

For our primary outcome, we performed an interrupted time series analysis using segmented regression (also known as piecewise regression or 'broken-line' regression) to assess for significant trends in the proportion of BPO procedures performed using each modality over time. We controlled for the first and the second order autoregressive effects. The higher order effects were not found to be significant. As there was a transition from the Canadian Classification of Diagnostic, Therapeutic and Surgical Procedures (CCP) coding to CCI coding in 2002 and this date corresponded with the introduction of laser prostatectomy in the region, we analyzed trends in the use of each procedure before and after 2002.

In order to analyze the trends in patient comorbidity over time, we used ordinal logistic regression with possible outcomes of RUB scores 0, 1, 2, 3, 4, and 5. Results were expressed as the odds ratio (OR) and 95% confidence interval (CI) associated with each year. To examine trends in patient age over time, we first used linear regression to examine changes in the mean age over time. We then used ordinal logistic regression to examine changes in the distribution across a categorical age variable (age <50 years, 50–60 years, 60–70 years, 70–80 years, and >80 years).

All statistical analyses were performed using SAS 9.3 (SAS Institute Inc., Cary, NC, U.S.). Statistical significance was set at $p < 0.05$.

Results

We identified a total of 136 459 men who underwent surgery for BPO between 1994 and 2014 in the province of Ontario. Most of the interventions TURP, representing 91.5% ($n = 124\,859$) of all BPO surgeries. Endoscopic laser

Table 1. Baseline demographic characteristics of men undergoing BPH surgery in Ontario, Canada from 1994–2014

Total cohort size (n)	136 459
Age (years)	
Mean (\pm SD)	71.2 (9.29)
Median (IQR)	72 (65–78)
Categorical, n (%)	
<50	1611 (1.2)
50–59	12 986 (9.5)
60–69	42 054 (30.8)
70–79	53 631 (39.3)
≥ 80	26 177 (19.2)
Income quintile, n (%)	
1 - Lowest	25 987 (19)
2	28 506 (20.9)
3	27 578 (20.2)
4	26 840 (19.7)
5 - Highest	27 099 (19.9)
Missing	449 (0.3)
Residence, n (%)	
Urban	116 536 (85.4)
Rural	19 789 (14.5)
Missing	134 (0.1)
RUB score, n (%)	
0 - Lowest	32 (0)
1	6 (0)
2	953 (0.7)
3	60 875 (44.6)
4	39 180 (28.7)
5 - Highest	35 413 (26)

BPH: benign prostatic hyperplasia; IQR: interquartile range; SD: standard deviation.

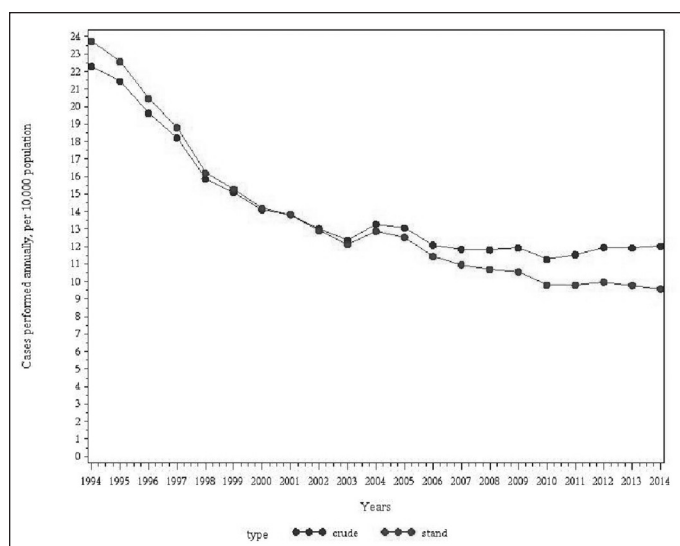


Fig. 1. Trends in the number of benign prostatic obstruction procedures being performed annually per 10 000 population.

prostatectomy was performed in 8526 (6.2%) of patients and open/laparoscopic prostatectomy was performed in 2003 (1.5%). Only 1071 (0.8%) patients received “other BPO intervention.” Most patients were aged 70 and older ($n=79\,808$, 58.5%), with a median age of 72 (Table 1). Nearly all patients had moderate (RUB=3) to very high (RUB=5) comorbidity (Table 1).

The number of BPO surgeries performed annually per 10 000 population declined over time, both in crude numbers and after age-standardization to the 2001 Ontario population (Fig. 1). Between 1994 and 2001, there was a significant decline in the age-standardized number of BPO surgeries (per 10,000 population) being performed annually (estimate=-1.5 per year; $p<0.0001$). While there continued to be a significant decline after 2002 (estimate=-0.3; $p=0.047$), the magnitude of change decreased significantly ($p<0.0001$). After stratification by age, there was a significant decline in the number of BPO surgeries between 1994 and 2001 for patients aged 50 and over (Fig. 2; Supplementary Table 1). For patients under the age of 50, there was no significant trend during this time period. After 2002, there was a modest decline in the number of BPO surgeries for patients in the 70–79-year and ≥ 80 -year age strata but no significant change for those younger than 70 (Fig. 2; Supplementary Table 1). The two- and five-year cumulative incidence of BPO surgeries significantly decreased over time among all age groups except men <50 years old (Table 2). The magnitude of these changes was largest among older men (age 70–79 and > 80 years), with reductions in excess of 50% (Table 2).

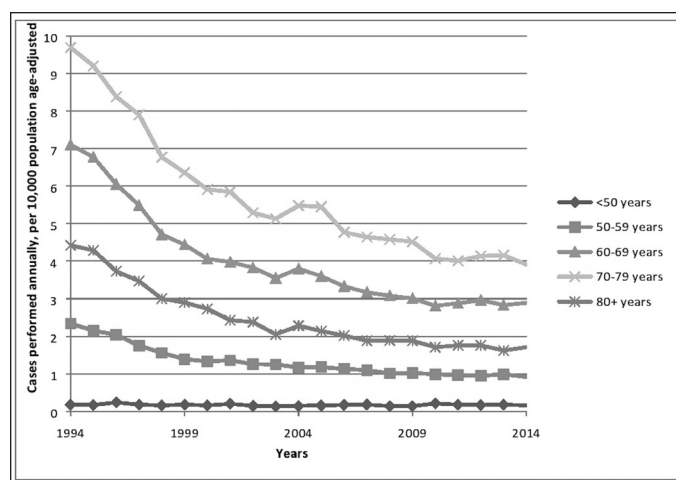


Fig. 2. Trends in the number of benign prostatic obstruction procedures being performed annually per 10 000 population stratified by patient age at the time of treatment.

Primary outcome

There were no statistically significant changes in the use of BPO interventions from 1994 (cohort inception) to 2001 (Table 3). TURP was the most common treatment modality throughout this period, with use of 97.2% in 1994 and 97.0% in 2001 (trend $p=0.67$). From 2001–2002, there was a statistically significant increase in the use of open/laparoscopic prostatectomy ($p=0.0008$), which may be attributable to changes in the coding schema; no such changes were observed for TURP ($p=0.32$), endoscopic laser prostatectomy ($p=0.89$), or other BPO treatments ($p=0.58$). From 2002–2014, there were significant changes in the two most common treatment modalities (Fig. 3). There was a statistically significant decline in the use of TURP from 92.1% in 2002 to 76.9% in 2014 ($p=0.027$). Correspondingly, there was an increased use of endoscopic laser prostatectomy after 2002 (3.5% to 21.9%; $p=0.0008$). The use of both open/laparoscopic prostatectomy and other BPO treatments declined from 2002–2014, though this was not statistically significant (Table 3).

Secondary outcomes

Among the whole study cohort, we observed a small but statistically significant trend towards higher comorbidity among patients undergoing BPO surgery over time (OR 1.005; 95% CI 1.003–1.007; $p<0.0001$). When we examined each intervention separately, there was a statistically significant trend for patients receiving TURP (OR 1.006; 95% CI 1.004–1.007; $p<0.0001$) and open/laparoscopic prostatectomy (OR 1.036; 95% CI 1.02–1.05; $p<0.0001$) to have higher RUB scores over time; however, this was not significant among patients undergoing endoscopic laser prostatectomy ($p=0.39$) or other BPO interventions ($p=0.43$).

Table 2. Two- and five-year cumulative incidence of requiring BPO surgery (per 1000 population) for men of a certain age in 1995, 2000, 2005, and 2010

Age group	1995	2000	2005	2010	Trend (p)
Two-year cumulative incidence of BPO surgery					
<50 years	0.07% (0.06–0.08)	0.06% (0.05–0.07)	0.06% (0.05–0.06)	0.07% (0.06–0.08)	0.26
50–59 years	2.98% (2.83–3.13)	1.92% (1.82–2.03)	1.66% (1.57–1.75)	1.38% (1.31–1.46)	<0.0001
60–69 years	13.20% (12.86–13.55)	8.39% (8.12–8.67)	7.27% (7.03–7.51)	6.01% (5.82–6.20)	<0.0001
70–79 years	24.79% (24.19–25.40)	16.66% (16.20–17.12)	14.45% (14.05–14.87)	11.44% (11.09–11.79)	<0.0001
> 80 years	28.59% (27.53–29.67)	18.14% (17.36–18.95)	14.57% (13.96–15.19)	12.28% (11.78–12.79)	<0.0001
Five-year cumulative incidence of BPO surgery					
<50 years	0.26% (0.24–0.28)	0.22% (0.20–0.24)	0.21% (0.19–0.23)	0.24% (0.22–0.26)	0.08
50–59 years	8.48% (8.23–8.73)	6.03% (5.84–6.22)	5.28% (5.12–5.44)	4.64% (4.50–4.78)	<0.0001
60–69 years	31.03% (30.50–31.56)	22.53% (22.09–22.97)	19.19% (18.80–19.58)	16.93% (16.61–17.25)	<0.0001
70–79 years	53.25% (52.37–54.15)	38.16% (37.47–38.86)	33.27% (32.65–33.90)	28.51% (27.96–29.07)	<0.0001
>80 years	51.05% (49.63–52.49)	34.87% (33.78–35.98)	28.37% (27.53–29.24)	25.69% (24.96–26.43)	<0.0001

BPO: benign prostatic obstruction.

Among the whole study cohort, there was a small but statistically significant shift in the age distribution towards an older age at the time of surgery (OR 1.003; 95% CI 1.001–1.004; $p=0.0004$). When we examined each intervention separately, there was a statistically significant trend for more patients receiving endoscopic laser prostatectomy (OR 1.016; 95% CI 1.004–1.028; $p=0.0087$) and TURP (OR 1.003; 95% CI 1.002–1.005; $p=0.0002$) to be in the older strata over time; however, there was no trend observed for patients undergoing open/laparoscopic prostatectomy ($p=0.81$) or other BPO procedures ($p=0.30$).

When we examined the mean age at the time of surgery, there was a small but statistically significant increase over time among the whole study cohort (0.01 years of age per year; $p=0.0014$). When we examined each intervention separately, there was a significant trend, with the mean age increasing over time among patients treated with endoscopic laser prostatectomy (0.11 years of age per year; $p=0.0005$) or TURP (0.01 years of age per year; $p=0.0022$), but this was not significant among those undergoing open/laparoscopic prostatectomy ($p=0.16$) or other BPO procedures ($p=0.56$).

Discussion

Using administrative data, this study characterizes trends in the surgical management of BPO surgery within a single-payer, government-funded healthcare system in Ontario, Canada. A total of 136 459 men with BPO were surgically managed between January 1, 1994 and December 31, 2014. Over the study period, TURP comprised the majority of interventions (91.5%), followed by endoscopic laser prostatectomy (6.2%), open/laparoscopic prostatectomy (1.5%), and other BPO procedures (0.8%). The total number of annual BPO surgeries per 10 000 patient population significantly decreased over time in patients over the age of 50.

No significant change in BPO surgical management trends were observed from 1994–2001; however, from 2002–2014, the number of TURP procedures significantly decreased (92.1% to 76.9%), corresponding with a significant increase in the use of endoscopic laser prostatectomy (3.5% to 21.9%). These findings are consistent with previously reported trends internationally,^{9–14} although contrast with prior work in Canada. Hueber et al captured Canada-wide trends in BPO management between 2007 and 2011.¹⁵ The authors observed no significant change in the use of TURP over the time period but did find a trend towards increased use of endoscopic laser prostatectomy.

Previous studies have identified factors that may influence the decision to use endoscopic laser prostatectomy over TURP, including increased patient age, higher surgeon case volume, and less patient comorbidity.^{11,16,17} Our study

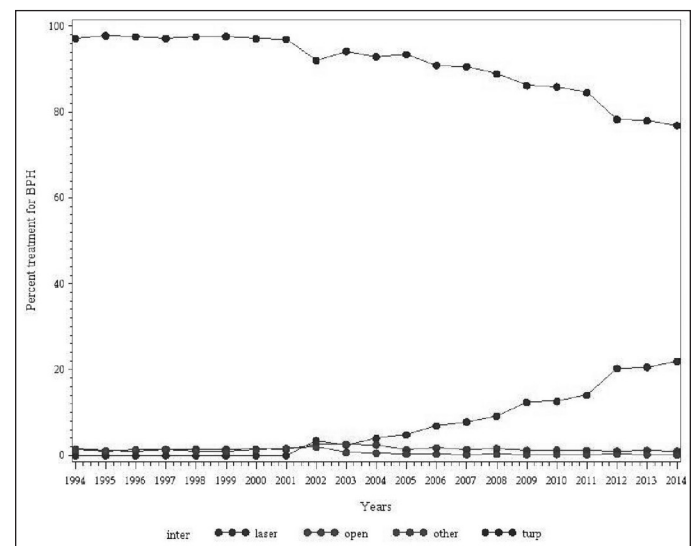
**Fig. 3.** Relative use of benign prostatic obstruction treatment modality from 1994–2014 in Ontario, Canada.

Table 3. Trends in the use of surgical interventions for BPO from 1994–2014

	Prior to 2002				After 2002				Difference in change per year (pre-2002 vs. post-2002) (p)
	Start of period	End of period	Change per year	p	Start of period	End of period	Change per year	p	
TURP	97.18%	96.98%	0.16	0.67	92.05%	76.93%	-1.41	0.027	0.003
Endoscopic laser prostatectomy	0%	0%	-0.10	0.71	3.45%	21.94%	1.67	0.0008	<0.0001
Open/lap prostatectomy	1.52%	1.36%	0.03	0.62	2.55%	0.98%	-0.13	0.07	0.008
Other	1.30%	1.66%	-0.05	0.51	1.96%	0.16%	-0.10	0.37	0.53

BPO: benign prostatic obstruction; TURP: transurethral resection of the prostate.

identified a significant trend towards an increase in patient comorbidity over time in the TURP cohort that is consistent with prior studies,^{15,18,19} although no significant trend in patient comorbidity was identified in the endoscopic laser prostatectomy cohort. While prior studies suggest that older patients are more likely to be treated with endoscopic laser prostatectomy compared to TURP, we found that trends in patient age at the time of surgery did not differ between the treatment groups, with a significant trend towards increased patient age at the time of surgery observed in both the TURP and endoscopic laser prostatectomy cohorts.

This study is one of the largest studies to date describing trends in the surgical management of BPO and was conducted in Ontario, Canada, which provides healthcare services free of cost to patients using a single-payer healthcare system. Several advantages are derived from this population-based study design. First, patient healthcare information is systematically recorded in provincial government databases, reducing recall/information bias. Second, inclusion/exclusion criteria were minimal; as such, the derived patient population reflects the true spectrum of surgical management of BPO. In addition, up to 40% of Canada's population resides within the province of Ontario,²⁰ with 40% of all BPO surgeries occurring within the province.¹⁵ In conjunction, these factors increase the generalizability of the results. Third, all BPO surgeries in the province were captured in the study, minimizing selection bias. Finally, validated coding schemas were used to accurately categorize surgical treatment modalities, further minimizing misclassification/information bias.

We recognize certain limitations of the study. Variables that may be driving the observed trends in the surgical management of BPO, including indication for surgery, are not captured in the databases. As such, although significant changes in BPO management trends were observed, we cannot comment on why this is occurring. Similarly, variables that may account for the observed increase in patient age or comorbidity were not captured in the study. We hypothesize that medical management may be delaying the age at which patients receive surgical management for BPO, with older patients tending to be more comorbid. However,

owing to funding eligibility of prescription medication in Ontario, data concerning medication use is not available for patients <65 years of age. As the purpose of this study was to accurately characterize BPO surgical management trends, age was not restricted to men over the age of 65 to ensure generalizability of the findings. We recognize that a small number of patients in the study were under the age of 50 (1.2%), in which a diagnosis of BPO is quite rare. It is possible that these patients received a BPO surgical intervention for a diagnosis other than BPO, although younger patients can present with symptomatic BPO. As we used validated coding schemas to identify patients with a diagnosis of BPO who received a BPO surgical intervention, including all age groups that can potentially present with symptomatic BPO serves to reduce selection bias in this study. Further, as there are very few patients under the age of 50 included in the study, study conclusions are unlikely to have been significantly affected by inclusion of this patient population. Final limitations include a lack of population-based data preceding the introduction of medical therapies for BPO available in Ontario and the inability to capture the effect changes in the surgical management of BPO have had on clinical outcomes (including treatment outcomes and complications). Further studies are planned to address these limitations.

Conclusions

Our population-based study highlights a shift in the surgical management of BPO over a 20-year period. Although TURP remains the most used modality overall, use has significantly decreased over time (presumably due to medical therapy), while management with endoscopic laser modalities has significantly increased. Further, a shift towards patients being older and more comorbid at the time of surgery was observed over the study period. This latter finding suggests that medical therapy may simply be delaying surgical intervention in some men and can aid practicing physicians in establishing appropriate treatment expectations and follow-up plans for men presenting with symptomatic BPO.

Competing interests: Dr. LaBossiere has been a speaker for Astellas and Pfizer. Dr. Herschorn has been an advisory board member and speaker for Allergan, Astellas, and Pfizer; has received honoraria from Astellas, Ipsen, and Ixaltis; and has participated in clinical trials supported by Astellas, Ipsen, and Ixaltis. Dr. Carr has been an advisory board member and speaker for Allergan, Astellas, Ferring, and Pfizer; and has participated in clinical trials supported by Allergan, Astellas, Aquinox, and Cook Medical. The remaining authors report no competing personal or financial interests related to this work.

This paper has been peer-reviewed

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Supplementary Table 1. Trends in the use of surgical interventions for BPO from 1994–2014, stratified by age group

	Prior to 2002				After 2002				Difference in change per year (pre-2002 vs. post-2002) (p)
	Start of period*	End of period*	Change per year	p	Start of period*	End of period*	Change per year	p	
<50 years	0.18	0.20	-0.003	0.15	0.15	0.16	0.002	0.47	0.025
50–59 years	2.34	1.36	-0.141	<0.0001	1.26	0.92	-0.023	0.36	<0.0001
60–69 years	7.10	3.98	-0.470	<0.0001	3.83	2.89	-0.081	0.17	<0.0001
70–79 years	9.69	5.85	-0.612	<0.0001	5.29	3.91	-0.144	0.009	<0.0001
≥80 years	4.42	2.43	-0.294	<0.0001	2.38	1.71	-0.056	0.045	<0.0001

*Age-standardized rate of BPO procedures per 10 000 population. BPO: benign prostatic obstruction.