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Original Article

Transurethral holmium laser enucleation of prostate shows remarkable efficacy in treating benign prostatic hyperplasia

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Abstract: Objective: To evaluate the effects of transurethral holmium laser enucleation of the prostate (HoLEP) in treating benign prostatic hyperplasia (BPH). Methods: This retrospective study included 100 BPH patients who visited Foshan Fosun Chancheng Hospital from January 2022 to June 2023. Patients were divided into two groups: 50 treated with transurethral resection of the prostate (control group) and 50 with transurethral HoLEP (observation group). We compared clinical efficacy, surgical parameters, maximum urinary flow rate (Qmax), post-void residual volume (PRV), prostate-specific antigen (PSA), hemoglobin (Hb), interleukin-6 (IL-6), C-reactive protein (CRP), International Prostate Symptom Score (IPSS), quality of life (QOL), and complication rates. Results: The observation group showed significantly reduced operative time, blood loss, catheterization duration, and hospitalization compared to the control group (all $P<0.05$). Postoperatively, Qmax was higher and PRV lower in the observation group (both $P<0.05$). PSA was lower, and Hb was higher in the observation group than those in the control group (both $P<0.05$). Both IL-6 and CRP levels increased post-surgery, but were significantly lower in the observation group (both $P<0.05$). The observation group also had better IPSS and QOL scores and a lower complication rate (16% vs. 56%, all $P<0.05$). Conclusion: HoLEP is an effective treatment for BPH, offering advantages such as reduced surgical time, lower complication rates, improved urodynamics, and better patient outcomes in terms of symptoms and quality of life.

Keywords: Holmium laser enucleation of the prostate, transurethral resection of the prostate, benign prostatic hyperplasia, efficacy

Introduction

The prostate gland is a key component of the male reproductive system, resembling a chestnut, primarily secreting prostatic fluid, and forming part of the posterior urethra. Benign prostatic hyperplasia (BPH) is a common benign condition in men, leading to urinary disturbances such as progressive dysuria, dysfunctional voiding, urgency, and frequency of urination [1]. While the exact etiology of BPH is not fully understood, it is believed to involve inflammatory factors, interactions between the prostatic interstitial glandular epithelium, growth factor and neurotransmitter effects, as well as an imbalance in cell proliferation and apoptosis, alongside sex hormones and their receptors [2]. Other risk factors include obesity, a history of cardiovascular disease, diabetes, and advanced age. With societal changes, including altered lifestyles, dietary habits, and an aging population, the incidence of BPH has been steadily increasing, drawing significant clinical attention [3].

Current treatments for BPH include medications and surgery. While drugs offer some benefit, they are slow-acting and often ineffective for moderate to severe cases, making surgery the preferred treatment [4]. The rise of minimally invasive surgery has led to a decline in traditional open surgeries, such as suprapubic prostatectomy, due to their high trauma and slow recovery [5]. The gold standard for BPH treatment is transurethral resection of the prostate (TURP), which involves using an electric resectoscope to remove the enlarged prostate tissue via the urethra. TURP effectively allevi-

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ates symptoms like difficulty urinating and rapidly increases urine flow [6]. However, complications such as urethral stricture, bladder neck contracture, urinary incontinence, and retrograde ejaculation can occur post-surgery, prompting the search for safer and more efficient treatments.

Recent advances in laser technology have introduced transurethral holmium laser enucleation of the prostate (HoLEP) as a promising alternative. HoLEP builds on the TURP technique, using a holmium laser (550 μm) delivered through optical fibers via an F26 holmium laser endoscope [7]. This laser enables precise tissue cutting while simultaneously stopping bleeding, preventing capsule penetration, and avoiding blood vessel injury. Unlike electrosurgery, there is no electric current during the procedure, and plasma or infusion fluid does not permeate the tissue. HoLEP offers advantages such as low glandular residue, reduced bleeding, and no electrocautery syndrome [8, 9]. Despite its potential, the therapeutic effects of HoLEP on BPH require further investigation. Therefore, this study aims to explore the effectiveness of HoLEP in treating BPH and provide valuable insights to improve the clinical management of BPH and enhance patients' quality of life.

Materials and methods

Case selection

In this retrospective study, 100 BPH patients who visited Foshan Fosun Chancheng Hospital between January 2022 and June 2023 were selected. They were divided into two groups based on the treatment method: the control group (50 patients) received TURP, and the observation group (50 patients) underwent transurethral HoLEP. The study was approved by the Foshan Fosun Chancheng Hospital Ethics Committee.

Inclusion criteria: 1). BPH confirmed by rectal examination, urine routine, serum prostate-specific antigen (PSA) test, and ultrasound. 2). Indications for TURP or HoLEP. 3). Normal heart, liver, and kidney functions. 4). Poor response to pharmacotherapy. 5). Surgery-naive patients. 6). Normal cognitive and communication abilities. 7). Complete clinical data.

Exclusion criteria: 1). Contraindications to TURP or HoLEP, or inability to tolerate surgery. 2). Co-existing urological conditions such as neurogenic bladder or severe urethral stenosis. 3). History of prostate or urethral surgery. 4). Abnormal coagulation function. 5). Hematological or immune system disorders. 6). Malignant tumors. 7). Severe hepatic or renal insufficiency, or mental disorders. 8). Systemic infections. 9). Other cardiovascular diseases or prostate malignancy.

Intervening methods

TURP in the control group: The patients were placed in the bladder stone position, and the surgical site was disinfected and irrigated with saline. After anesthesia, the resectoscope was inserted through the urethra to inspect the prostate, seminal caruncle, and hyperplasia of the middle lobe and both lateral lobes. The resectoscope's power was set to 150 W for cutting and 90 W for coagulation. A cutting mark was made at six points along the bottom of the proximal anterior margin of the seminal caruncle. Resection of the middle lobe and both lateral lobes was performed, followed by bleeding control, trimming of the prostate apex, and evacuation of the resected tissue. The bladder was irrigated with saline, and a catheter was placed.

HoLEP in the observation group: Versa Pulse PowerSuite Holmium Laser (80/100W, Israel Lumenis Limited, Model: YZB/ISR 6855-2012) was used. After routine disinfection and towel placement, the patients were anesthetized, and the bladder stone position was selected. The holmium laser power was set between 2.5-80 W, with a frequency of 25 Hz and energy of 2.5 J. The urethra, bladder, and prostate were closely examined. Using the seminal caruncle as a reference, the urethral mucosa was dissected 0.5-1 cm in front of the seminal caruncle. The left lobe was incised with the laser to define the boundary between the hyperplastic glands and prostate tissue. The hyperplastic glands from both the left and right lobes were then completely excised along the prostate capsule. Hemostasis was performed during the procedure. The urethral mucosa was dissected at the 12 o'clock position, and the connection between the bladder mucosa and hyperplastic gland was severed. The middle lobe was

pushed into the bladder opening for excision, with careful inspection and repair of any trauma. The hyperplastic tissue was crushed and aspirated using a pulverizer. A catheter was placed, and the surgical instruments were withdrawn.

Data collection and outcome measurements

(1) Clinical efficacy: Markedly effective: The patient's surgery proceeds smoothly, and urination function significantly improves postoperatively. Symptoms of prostatic hyperplasia are essentially resolved, with no adverse reactions or complications.

Relieved: The surgery goes well, with minimal tissue damage and bleeding. Postoperatively, urination function is improved, and symptoms of prostatic hyperplasia are controlled, with mild adverse reactions or complications.

Ineffective: The surgery is complex, with significant tissue damage and bleeding. Postoperative urination function is not relieved, and symptoms of BPH persist, along with severe adverse reactions.

Total effective rate = (Number of markedly effective cases + number of relieved cases)/ Total number of cases × 100%.

(2) Surgery-related indexes: The following parameters were compared between the two groups: operation time, gland removal mass, intraoperative bleeding, indwelling urinary catheter time, and hospitalization time.

(3) Urodynamics: The maximum urinary flow rate (Qmax) for both groups was measured before and 6 months after surgery using an uroflowmeter (Shanghai Hanfei Medical Equipment Co., Ltd., UT60). The residual urine volume (PRV) before and after surgery was recorded using catheter derivation for both groups.

(4) PSA, hemoglobin (Hb), interleukin (IL)-6, and C-reactive protein (CRP) levels: A 3 mL sample of fasting venous blood from both groups was collected before and after surgery. The blood was left to stand at room temperature for 1 hour, then centrifuged at 3,000 rpm for 10 minutes using a VM-1400-2KB centrifuge. The serum was stored at -80°C for further analysis. Serum PSA, IL-6, and CRP levels were measured using enzyme-linked immunosorbent assay (ELISA), following the manufacturer's instructions (Shanghai Jianglai Biotechnology Co., Ltd., 1536127757; Shanghai Genetimes Biotechnology Co., Ltd., EH004, EH029). Hb levels were detected using a fully automated biochemistry analyzer (BS400, Myriad Healthcare).

(5) International prostate symptom score (IPSS) [10] and quality of life (QOL) [11]: IPSS and QOL scores were assessed for both groups before and 6 months after surgery. The IPSS scale, with a maximum score of 35, evaluates lower urinary tract symptoms; higher scores indicate more severe symptoms. The QOL scale, with a maximum score of 100, evaluates factors such as urinary distress, sleep quality, daily life, pain, and overall health; higher scores indicate better quality of life.

(6) Complication rate: The occurrence of complications such as urethral stricture, urinary incontinence, urinary tract infection, and hematuria was recorded and compared between the two groups.

Primary outcome measures: Clinical efficacy, surgery-related parameters, PSA, Hb, IL-6, CRP levels, and complication incidence.

Secondary outcome measures: Urodynamics, IPSS scores, and QOL scores.

Statistical methods

Statistical analysis was performed using SPSS 18.0. Measurement data were expressed as mean ± standard deviation ($\bar{x} \pm sd$), and within-group comparisons before and after surgery were conducted using paired t-tests. Count data were presented as frequency (n) or percentage (%) and analyzed using the χ^2 test. A *p*-value of <0.05 was considered statistically significant.

Results

Comparison of baseline data

No significant differences were observed between the two groups in terms of average age, body mass index (BMI), disease duration, or prostate volume (all P>0.05, **Table 1**).

Table 1. Comparison of General data

General data	Control group (n=50)	Observation group (n=50)	t vale	*P* value
Average age (year)	58.98±5.41	59.59±5.34	0.567	0.572
Average BMI (kg/m^2)	23.19±4.33	23.16±4.37	0.034	0.973
Average course of disease (year)	2.64±0.78	2.70±0.88	0.361	0.719
Average prostate volume (mL)	55.99±12.62	56.72±12.32	0.293	0.770

Note: BMI, body mass index.

Table 2. Comparison of clinical efficacy [n (%)]

Clinical efficacy	Control group (n=50)	Observation group (n=50)	X^2 value	*P* value
Markedly effective	22 (44.00)	25 (50.00)	-	-
Relieved	16 (32.00)	21 (42.00)	-	-
Ineffective	12 (24.00)	4 (8.00)	-	-
Total effective rate	38 (76.00)	46 (92.00)	4.762	0.029

Table 3. Comparison of surgical related indicators ($\bar{x}\pm sd$)

Project	Control group (n=50)	Observation group (n=50)	t vale	*P* value
Surgical time (min)	115.31±15.59	98.28±15.23	5.525	<0.001
Gland removal mass (g)	52.61±4.04	61.19±5.28	9.126	<0.001
Intraoperative bleeding (mL)	205.67±35.42	164.90±33.21	5.937	<0.001
Duration of indwelling urinary catheter (d)	4.40±1.58	3.46±1.52	3.032	0.003
Length of stay (d)	8.20±0.67	5.47±0.34	25.693	<0.001

Table 4. Comparison of urodynamics before and after surgery ($\bar{x}\pm$sd)

Indexes		Control group (n=50)	Observation group (n=50)
Qmax (mL/s)	Before surgery	8.47±1.49	8.59±1.55
	After surgery	17.87±2.89*	23.50±3.10*,#
PRV (mL)	Before surgery	135.50±15.49	134.30±14.58
	After surgery	41.33±6.52*	34.31±5.40*,#

Note: *P<0.05 compared with before surgery; #P<0.05 compared with control group. Qmax, maximum urinary flow rate; PRV, residual urine volume.

Comparison of clinical efficacy

The total effective rates in the control and observation groups were 76.00% and 92.00%, respectively. The observation group showed a significantly higher total effective rate compared to the control group (P<0.05, **Table 2**).

Comparison of surgery-related indicators

The observation group had shorter surgical time, less intraoperative bleeding, shorter indwelling urinary catheter time, and a shorter hospital stay compared to the control group. Additionally, the gland removal mass was significantly higher in the observation group (all P<0.05, **Table 3**).

Comparison of urodynamics before and after surgery

Before surgery, no significant differences were observed between the groups in terms of Qmax and PRV (both P>0.05). After surgery, both groups showed an increase in Qmax and a decrease in PRV (both P<0.05). Notably, the observation group had higher Qmax and lower PRV compared to the control group (both P<0.05, **Table 4**).

Comparison of PSA and Hb levels before and after surgery

No significant differences were observed in PSA and Hb levels between the groups before

Table 5. Comparison of PSA and Hb levels before and after surgery ($\bar{x}$±sd)

Indexes		Control group (n=50)	Observation group (n=50)
PSA (ng/mL)	Before surgery	2.94±0.98	2.66±0.97
	After surgery	2.12±0.95*	1.63±0.91*,#
Hb (g/L)	Before surgery	140.28±15.67	142.69±11.04
	After surgery	116.37±13.13*	128.37±14.34*,#

Note: *P<0.05 compared with before surgery; #P<0.05 compared with control group. PSA, prostate-specific antigen; Hb, hemoglobin.

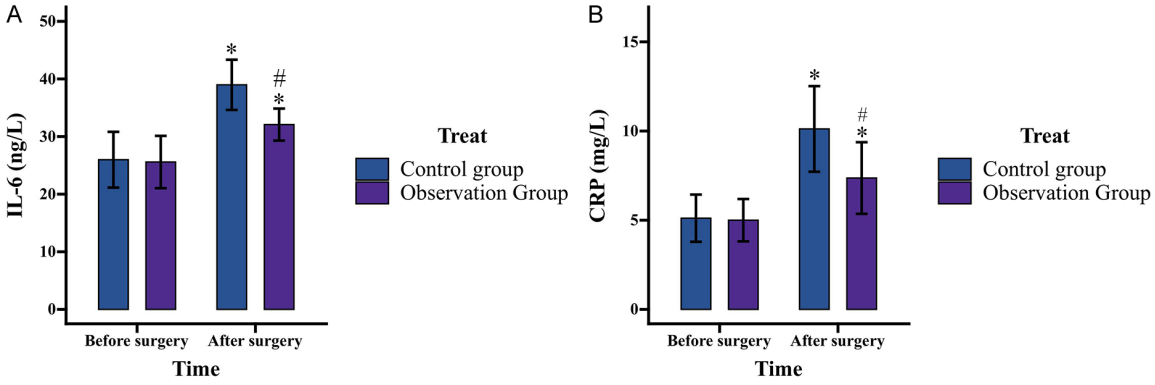

Figure 1. Comparison of serum inflammatory factors before and after surgery. A. Pre- and post-operative IL-6 levels in the two groups. B. Pre- and post-operative CRP levels in the two groups. Note: IL-6, interleukin-6; CRP, C-reactive protein. *P<0.05 vs. the level before surgery; #P<0.05 vs. the control group.

surgery (both P>0.05). After surgery, PSA and Hb levels significantly decreased in both groups (both P<0.05). However, PSA levels were lower and Hb levels were higher in the observation group compared to the control group, with statistically significant differences (both P<0.05, **Table 5**).

Comparison of serum inflammatory factors before and after surgery

Before surgery, there were no significant differences in IL-6 and CRP levels between the two groups (both P>0.05). Postoperatively, both groups showed significant increases in IL-6 and CRP levels (both P<0.05). However, the postoperative levels of IL-6 and CRP were significantly lower in the observation group compared to the control group (both P<0.05). For specific data, refer to **Figure 1**.

Comparison of IPSS and QOL scores before and after surgery

Before surgery, there were no significant differences in IPSS and QOL scores between the two groups (both P>0.05). After surgery, both groups showed a decrease in IPSS scores and an increase in QOL scores (both P<0.05). The observation group had significantly lower IPSS scores and higher QOL scores compared to the control group (both P<0.05, **Table 6**).

Comparison of complications

The complication rate in the observation group was significantly lower than that in the control group (P<0.05, **Table 7**).

Discussion

BPH is a common urological disease, particularly prevalent among middle-aged and elderly males. It primarily manifests as hematuria, frequent urination, dysuria, and voiding obstruction, necessitating active and effective treatment. If untreated, BPH can lead to complications such as bladder dysfunction, bladder stones, urinary tract infections, urinary retention, and renal impairment, posing significant risks to patients' physical health and quality of life [12]. Surgery remains the primary treatment for BPH, with TURP being the most established procedure. TURP effectively removes

Table 6. Comparison of IPSS and QOL scores before and after surgery ($\bar{x}$±sd, points)

Project		Control group (n=50)	Observation group (n=50)
IPSS scores	Before surgery	27.28±2.00	27.17±1.92
	After surgery	11.17±1.49*	7.14±1.18*,#
QOL scores	Before surgery	55.68±2.49	56.17±2.55
	After surgery	80.47±3.03*	91.28±3.09*,#

Note: *P<0.05 compared with before surgery; #P<0.05 compared with control group. IPSS, International Prostate Symptom Score; QOL, Quality of Life Score.

Table 7. Comparison of complications [n (%)]

Adverse reactions	Control group (n=50)	Observation group (n=50)	X^2 value	*P* value
Urethral stricture	10 (20.00)	2 (4.00)	-	-
Urinary incontinence	8 (16.00)	4 (8.00)	-	-
Urinary tract infection	4 (8.00)	0 (0.00)	-	-
Hematuria	6 (12.00)	2 (4.00)	-	-
Total incidence	28 (56.00)	8 (16.00)	17.361	<0.001

proliferative tissue causing obstruction, is relatively quick, and helps prevent further tissue proliferation, thereby controlling disease progression [13]. However, TURP has limitations, including patient selection constraints, significant bleeding, post-surgery thermal tissue damage, electrosurgical burns, glandular residue, and potential for secondary surgeries, all of which can negatively impact patient outcomes [14].

HoLEP combines the advantages of both open prostatectomy and transurethral surgery. It uses cutting tabs or microscopic sheaths to directly peel hyperplastic prostatic tissue, allowing for complete removal within the prostatic capsule. This technique reduces glandular residue, minimizes bleeding, requires smaller incisions, and results in fewer complications, facilitating better postoperative recovery [15, 16]. The results of this study indicate that HoLEP significantly improves clinical efficacy, shortens surgery time, reduces urethral retention, minimizes bleeding, and shortens hospital stay. It also enhances urodynamics, alleviates abnormal serum inflammatory responses post-surgery, improves clinical symptoms, and lowers the risk of complications. Given the limited research on HoLEP for treating BPH, this study aims to fill this gap.

BPH, a urological condition, is closely associated with age; the older the individual, the higher the risk of developing BPH. The disease mainly manifests as lower urinary tract obstruction, and if left untreated, it can lead to long-term renal damage, ureteral reflux, and bladder instability, with surgery being the treatment of choice [17, 18]. Abedi et al. [19] found that compared to TURP, HoLEP significantly reduced hospitalization time and bleeding while having minimal impact on Hb levels. Yuk et al. [20] reported that HoLEP improved urinary symptoms, PRV, and Qmax in BPH patients with preoperative urinary retention. Mostafa et al. [21] observed improvements in urodynamic parameters and IPSS scores following HoLEP treatment in BPH patients with voiding symptoms.

In this study, the observation group showed a significantly higher total effective rate than the control group. Additionally, the observation group had shorter surgical times, less intraoperative blood loss, shorter indwelling catheter times, and shorter hospital stays. The gland removal mass was also higher in the observation group. Postoperatively, Qmax, IL-6, and CRP increased in both groups, while PRV, PSA, Hb, and IPSS scores decreased. However, the observation group consistently showed superior results, which aligns with findings from Abedi, Yuk, and Mostafa, supporting HoLEP's effectiveness in treating BPH [19-21].

Although it is the gold standard for BPH treatment due to its minimal pain, good efficacy, and low trauma, TURP still has certain drawbacks. For instance, during TURP, 5% mannitol is used

as the irrigation fluid, which can be absorbed by the body and may cause electrolyte disturbances, leading to electrocautery syndrome and even fatal outcomes. TURP also causes significant bleeding and is unsuitable for patients with coagulation disorders or those on long-term anticoagulant therapy. Furthermore, the use of high-frequency electrosurgery may interfere with pacemaker signals, rendering TURP inappropriate for patients with pacemakers [22, 23]. The working medium of HoLEP is holmium, and the holmium laser is a type of high-energy pulsed laser with its medium contained in garnet crystals. The solid-state laser emitted has a wavelength of 2140 nm and a pulse duration of 0.25 ms, with the laser being transmitted through a soft optical fiber [24]. HoLEP achieves bloodless cutting through laser energy, significantly reducing intraoperative bleeding and demonstrating strong potential for clinical application [25].

Holmium lasers offer several advantages in treatment: unlike other procedures where electrode desiccation syndrome occurs due to the absorption of non-electrolyte irrigation fluids, HoLEP uses physiological saline, which minimizes the occurrence of desiccation syndrome. The holmium laser exhibits coagulation properties when positioned 2-3 mm away from tissues, aiding in hemostasis during surgery. Additionally, its tissue penetration depth is only 0.44 mm, causing minimal thermal damage to superficial tissues while sparing deeper structures. The laser also lacks electrical conductivity, preventing electrical sparks and reducing the likelihood of occlusive nerve reflexes, thus enhancing surgical safety [26, 27].

A challenge in BPH surgery is the treatment of the prostate tip, particularly as the anterior lobe is located near the external urethral sphincter. Injury to the sphincter can lead to urinary incontinence, which is often irreversible and can negatively affect surgical outcomes. However, because of the shallow tissue penetration of the holmium laser, it minimizes damage to the urinary sphincter while ensuring adequate resection of the prostate tip, thus leading to optimal surgical results [28].

This study confirms that HoLEP for BPH patients effectively improves clinical outcomes, enhances urodynamics, alleviates clinical symptoms, and regulates abnormal PSA, Hb, IL-6, and CRP levels. Furthermore, the QOL scores increased in both groups post-treatment, with the observation group showing significantly higher QOL scores compared to the control group. Additionally, the complication rate in the observation group was lower than that in the control group, indicating that HoLEP is both safe and effective for BPH treatment.

The rationale behind these results lies in the shallow penetration depth of the HoLEP laser, which reduces thermal damage and protects deeper tissues. Holmium lasers quickly raise tissue temperature to achieve vaporization of the target lesion without generating electric sparks, providing high safety and effectiveness. HoLEP also allows for precise resection of hyperplastic prostate tissue without damaging surrounding structures, which contributes to improved patient outcomes [29, 30].

However, the study is limited by a small sample size, which may introduce potential biases in the results. Additionally, there was no long-term follow-up to assess the prolonged effects of HoLEP on BPH patients. Future research should focus on expanding the sample size and conducting long-term follow-ups to further validate these findings.

In conclusion, HoLEP not only enhances clinical efficacy and improves several surgery-related parameters, but also alleviates serum inflammatory responses, promotes better urodynamics, improves QOL, and reduces the complication rate, making it a promising treatment option for BPH.

Disclosure of conflict of interest

None.

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