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REVIEW

Efficacy and safety of blue laser vaporization of the prostate for benign prostatic hyperplasia: a systematic review and meta-analysis

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Objective: *While novel 450 nm blue laser vaporization of the prostate (BLVP) has emerged as a promising treatment for benign prostatic hyperplasia (BPH), comprehensive evidence-based validation remains lacking. Therefore, this study aims to evaluate the efficacy and safety of BLVP for BPH.*
Methods: *A systematic search was conducted in PubMed, Cochrane Library, Embase, Web of Science, China National Knowledge Infrastructure (CNKI), VIP, and Wanfang database up to 1 September 2025 (an updated search was performed on 31 December 2025). Single-arm meta-analyses summarized the absolute efficacy and safety of BLVP. For the comparison of BLVP with other surgical procedures, head-to-head meta-analyses or descriptive systematic reviews were performed based on the homogeneity of studies.*
Results: *Across 23 included studies (1713 participants), single-arm meta-analysis showed favorable perioperative outcomes: mean operative time (26.46 min), bladder irrigation time (14.96 h), catheterization time (2.67 d), and hemoglobin drop (6.96 g/L). Postoperative IPSS, Q_{max}, PVR, and QoL significantly improved with low complication rates. Compared with transurethral resection of the prostate (TURP), BLVP demonstrated favorable outcomes regarding shorter operation, irrigation, and catheterization times, less hemoglobin loss, and shorter hospital stays (all $p < 0.05$). While urinary functional recovery was comparable, BLVP exhibited lower risks of urinary incontinence (OR = 0.38) and secondary bleeding (OR = 0.15). Additionally, BLVP better preserved sexual function, demonstrating higher International Index of Erectile Function-5 (IIEF-5) scores at 6 months and a significantly lower incidence of retrograde ejaculation (OR = 0.07) than TURP. Preliminary studies suggest that the efficacy of BLVP is similar to that of 1470 nm and greenlight lasers.*
Conclusion: *Preliminary evidence suggests that BLVP appears to be a safe and effective minimally invasive procedure for BPH, demonstrating favorable trends in perioperative recovery and sexual function preservation. However, due to a lack of high-quality RCTs and low-to-moderate certainty of evidence, BLVP's equivalence or superiority to TURP remains inconclusive, warranting further large-scale trials.*

Key Words: benign prostatic hyperplasia, blue laser vaporization of the prostate, transurethral resection of the prostate, greenlight laser vaporization of the prostate, 1470 nm diode laser enucleation of the prostate, systematic review, meta-analysis

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Introduction

Benign prostatic hyperplasia (BPH) is one of the most common diseases among middle-aged and elderly men worldwide.[1,2] With the intensification of global population aging, the number of BPH patients is

steadily increasing.[1,2] It causes lower urinary tract symptoms (LUTS) such as frequency, urgency and nocturia, which seriously impair the quality of life of patients.[3] The global burden of disease is rising rapidly.[4] Surgery is one of the main treatment methods for BPH. For a long time, conventional monopolar transurethral resection of the prostate (TURP) has been regarded as the "gold standard" for the treatment of BPH. However, many patients experience decisional regret following postoperative complications.[5] In recent years, emerging technologies such as bipolar TURP, Holmium laser enucleation of the prostate (HoLEP), and greenlight laser vaporization of the prostate (GLVP) have surpassed conventional monopolar TURP in many aspects, but they still have certain limitations: bipolar TURP has similar risks of bleeding and urethral stricture to those of conventional TURP.[6] Although HoLEP has a remarkable therapeutic effect on large-volume prostates, its learning curve is steep and it has high requirements for the surgeon.[7,8] As for GLVP, its vaporization efficiency and re-treatment rate are still subjects of controversy.[9–11] Therefore, in clinical practice, it is still necessary to explore safer, more efficient and more accessible surgical procedures.

Recently, the new 450 nm semiconductor blue laser treatment system has emerged as a promising option. The 450 nm blue laser possesses specific absorption characteristics: it is highly absorbed by hemoglobin but exhibits minimal absorption by water. Therefore, theoretically, it has the features of shallow tissue penetration, high vaporization efficiency and excellent hemostatic effect.[12,13] Early studies suggest it holds great promise for the treatment of BPH. However, its clinical application time is relatively brief, and it lacks sufficient evidence-based medical proof to support it.[14–17] Therefore, this study adopted systematic review and meta-analysis to comprehensively search for and integrate clinical studies on 450 nm blue laser vaporization of the prostate (BLVP) for the treatment of BPH, and systematically evaluate its efficacy and safety in improving LUTS, aiming to comprehensively provide existing evidence to guide clinical decision-making for urologists.

Methods

The study protocol was registered with PROSPERO (CRD420251237676). We conducted the meta-analysis in accordance with the PRISMA checklist (Supplementary Material 1).

Inclusion and exclusion criteria

To be included in this study, the criteria were: (1) Patients with BPH who have been clinically diagnosed and have surgical indications. (2) Received 450 nm BLVP treatment. (3) It can be without a control group or receive conventional surgical treatment, such as TURP, GLVP, etc. (4) The study is required to report at least one of the following outcome measures, including 1) perioperative indicators: operative time, bladder irrigation time, catheterization time, hemoglobin drop, hospital stay or postoperative hospital stay; 2) Indicators related to urination and sexual function: International Prostate Symptom Score (IPSS),[18,19] maximum urinary flow rate (Q_{max}), quality of life (QoL), post-void residual volume (PVR), and International Index of Erectile Function-5 (IIEF-5);[18,19] 3) Complication rates: capsular perforation, bladder mucosal injury, urinary retention, urinary incontinence, urinary tract infection, urethral stricture, retrograde ejaculation, etc. (5) The study design was single-arm study, randomized controlled trial (RCT), or non-randomized study of interventions (NRSI).

The exclusion criteria are as follows: (1) Studies lacking complete data (letters, reviews, comments, and conference papers, etc.). (2) Preprints or other unpublished research results that have not undergone peer review.

Literature retrieval strategy

We searched PubMed, The Cochrane Library, Embase, Web of Science, China National Knowledge Infrastructure (CNKI), VIP (https://qikan.cqvip.com/), and WanFang databases up to 1 September 2025 (updated search was performed prior to data analysis on 31 December 2025, to ensure the inclusion of the latest evidence). Search terms included: Prostatic hyperplasia, prostate hyperplasia, prostatic enlargement, blue laser, 450 nm, etc. A detailed search strategy is provided in Supplementary Material 2.

Literature screening and data extraction

The screening of literature and subsequent data retrieval were conducted independently by two researchers in strict accordance with the predefined inclusion and exclusion criteria. Following the initial selection, the results were cross-verified. Any discrepancies were resolved through collaborative discussion until a consensus was achieved, with the involvement of a third researcher for final adjudication when necessary. The information extracted from the eligible studies encompassed first author, publication year, study design, sample size, baseline characteristics (age, prostate volume, IPSS, Q_{max}, PVR,

QoL, IIEF-5, etc.). All outcomes specified in the inclusion criteria were systematically extracted to facilitate the subsequent meta-analysis.

Risk assessment of bias in the included studies

The quality assessment of all included literature was independently conducted by two researchers. Any inconsistency was resolved through discussion or consultation with a third researcher. For single-arm studies without a control group, the Quality Assessment Tool for Pre-Post Studies With No Control Group, designed by the National Institutes of Health (NIH), was used for the assessment, covering the risk of bias in 12 core areas.[20] For NRSIs, we used the Risk of Bias in Non-randomized Studies of Interventions version I (ROBINS-I) recommended by Cochrane to assess the risk of bias in the following seven domains: bias due to confounding, bias in selection of participants into the study, bias in classification of interventions, bias due to deviations from intended interventions, bias due to missing data, bias in measurement of outcomes, and bias in selection of the reported result.[21] For RCTs, Version 2 of the Cochrane Risk of Bias tool (RoB 2.0) was used for quality evaluation.

Statistical analysis

All data analyses were conducted through the "meta" package (version 8.2-0) in R software (version 4.4.2). For continuous variables, the Mean difference (MD) was used as the pooled effect. For binary variables, the odds ratio (OR) was calculated using the Mantel-Haenszel method for NRSI,[22] whereas the relative risk (RR) was used for RCTs. In addition, the complication rates in the single-arm meta-analysis were combined through the metaprop function. To handle the zero-frequency events of some indicators in multiple studies, the Freeman-Tukey double inverse sine transform was used to pool the rates.[23] All effect sizes were reported with 95% Confidence intervals (95% CI) and *p*-values. For studies that only provided the median, 25th and 75th percentiles, the method provided by Wan et al. was used to estimate the mean and standard deviation for pooled analysis.[24] Heterogeneity between studies was evaluated by the I^2 test. If $I^2 \geq 50\%$, it was considered that significant heterogeneity might exist. Given that the random-effects model can provide estimates similar to those of the fixed-effects model when heterogeneity is low, and its statistical results are usually more conservative, this study uniformly adopted the random-effects model for all analyses to ensure the robustness and generalizability of findings. A two-sided test with a $p < 0.05$ was considered statistically significant.

To reduce the risk of bias caused by duplicate publication or overlapping study populations, we conducted strict reviews in aspects such as study design, study time, study location, inclusion and exclusion criteria, and data similarity. For the data on duplicate publication, only the literature with a more rigorous methodology and more complete data reporting was retained. Subgroup analyses were designed based on possible sources of heterogeneity.

In single-arm meta-analyses, subgroup analyses were performed based on the prostate volume reported in the included studies, categorizing them into three groups: small volume (<30 mL), large volume (>80 mL), and mixed volume (unspecified criteria or no specific volume limitations). For comparative meta-analyses, stratification was performed based on the control group's energy platform (monopolar or bipolar systems). Due to the insufficient number of studies (<10) for all outcomes, funnel plot tests and Egger's tests were not conducted to avoid unreliable estimates of publication bias arising from low statistical power.[25,26]

Results

Literature screening process and results

A total of 159 records or registered trials were initially identified. After screening, 23 studies were finally included, involving a total of 1713 participants, among whom 1206 patients received BLVP. The eligible studies included 12 single-arm studies[27–38] and 11 comparative studies. No RCTs were retrieved. NRSIs included five comparisons with monopolar TURP,[39–43] four with bipolar TURP,[14–17] and two with GLVP and 1470 nm diode laser enucleation of the prostate (1470 nm DiLEP), respectively.[44,45] The flowchart of literature screening is shown in Figure 1.

Basic characteristics of the included studies and risk assessment of bias

The baseline characteristics of the included studies are detailed in Table 1. We evaluated 12 single-arm studies using the NIH quality assessment tool (Table A1). All studies clearly stated their research objectives, inclusion and exclusion criteria, outcome assessment, and they employed appropriate statistical methods. The main sources of risk for most studies include: the lack of sample size estimation, the unclear description of the consecutive patient enrollment and blinding implementation, and the reporting of outcomes at a single time point. In addition, the loss to follow-up rate in one study was higher than 20%.

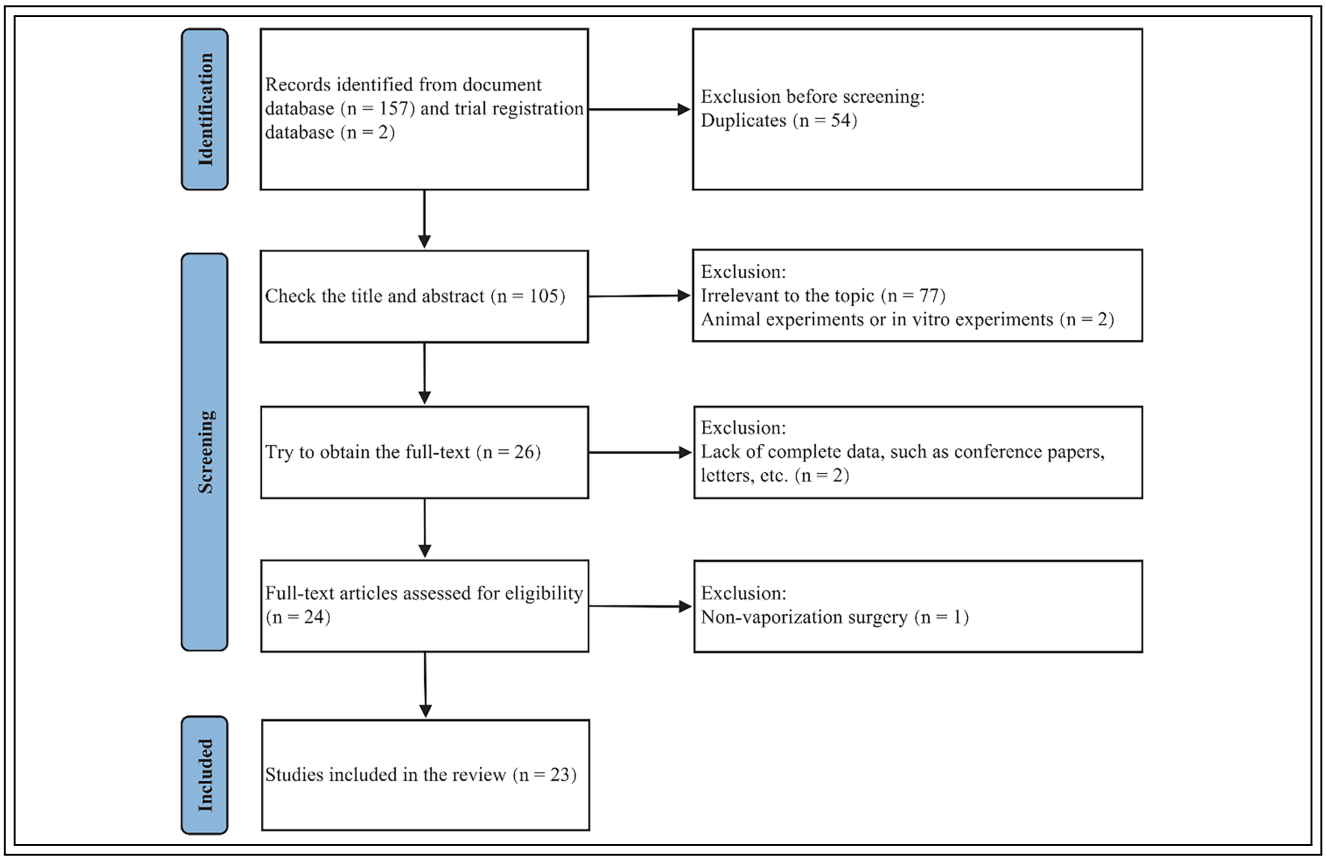

FIGURE 1. Flow diagram of the process of study selection

For 11 non-randomized controlled trials, we evaluated them using the ROBINS-I (Table A2). The results showed that 9 studies were rated as having a moderate risk of bias and 2 as having a serious risk of bias. The risks mainly stem from insufficient control of potential confounding factors, reporting only outcome data at a single time point, or incomplete reporting of key outcome data, etc.

Overall, the quality of evidence is limited by the retrospective design of most studies. While selection bias and confounding were partially addressed in some studies, the lack of randomization and blinding in outcome assessments introduced a moderate-to-serious risk of bias.

Efficacy and safety of BLVP in single-arm studies

The analysis results of perioperative-related indicators (Figure 2) showed that the mean operative time was 26.46 min (95% CI: 20.51 to 32.42), the mean bladder irrigation time was 14.96 h (95% CI: 7.14 to 22.78), and the catheterization time was 2.67 days (95% CI: 1.78 to 3.57). The mean postoperative hospital stay was 4.00 days (95% CI: 3.30 to 4.69). The mean hemoglobin drop after the operation was 6.96 g/L (95% CI: 4.18 to 9.75). All of these perioperative indicators exhibited high heterogeneity ($I^2 \geq 50\%$).

Regarding the indicators related to urinary function, we conducted a combined analysis of the follow-up results at 1, 3, 6 and 12 months after the operation (Figure 3). All efficacy indicators of urinary function at each time point showed high heterogeneity ($I^2 \geq 50\%$). The mean IPSS at 1 month after the operation was 10.45 (95% CI: 9.22 to 11.68), and dropped to 7.72 (95% CI: 4.58 to 10.86) at 3 months. This level remained stable at 7.74 (95% CI: 2.57 to 12.92) during the 6-month follow-up. Only two studies reported IPSS at 12 months, with a mean of 9.49 (95% CI: 3.29 to 15.68). The mean values of Q_{max} at 1, 3, 6 and 12 months after the operation were 19.83 mL/s (95% CI: 17.47 to 22.19), 19.01 mL/s (95% CI: 15.38 to 22.63), 17.94 mL/s (95% CI: 13.95 to 21.94), and 19.03 mL/s (95% CI: 12.90 to 25.17), respectively. The mean PVR at 1, 3, 6, and 12 months after surgery were 12.89 mL (95% CI: 7.91 to 17.86), 11.74 mL (95%

TABLE 1. **Baseline characteristics of the included studies**

Study	Design	Group	Sample size	Age (years)	Mean prostate volume (mL)	Preoperative IPSS (score)	Preoperative Q_{max} (mL/s)	Preoperative PVR (mL)	Preoperative QoL (score)	Preoperative IIEF-5 (score)
Xu et al. 2025[27]	Retrospective	BLVP (Single-arm)	132	67.21 ± 3.56	56.86 ± 4.32	26.23 ± 2.47	8.68 ± 1.55	69.39 ± 15.48	4.63 ± 0.79	18.27 ± 1.92
Cao et al. 2025[28]	Retrospective	BLVP (Single-arm)	32	75.4 ± 13.2	79.6 ± 33.1	23.2 ± 5.9	8.9 ± 3.6	72.3 ± 15.9	4.2 ± 0.3	/
Yao et al. 2024[29]	Retrospective	BLVP (Single-arm)	34	68.4 ± 9.1	26.4 ± 3.5	28.0 (23.8, 31.0)	4.5 (3.0, 8.0)	45.0 (20.0, 120.0)	5.0 (4.0, 5.0)	5.5 (0, 12.0)
Zhang et al. 2024[30]	Retrospective	BLVP (Single-arm)	30	81.2 ± 2.4	69.0 ± 15.4	26.28 ± 2.22	8.15 ± 2.09	397.89 ± 8.47	5.25 ± 0.85	/
Tu et al. 2024[31]	Retrospective	BLVP (Single-arm)	30	73.13 ± 6.42	104.5 ± 14.52	27.67 ± 2.20	6.20 ± 1.81	74.83 ± 15.67	5.07 ± 0.69	/
Wang et al. 2024[32]	Retrospective	BLVP (Single-arm)	40	75.9 ± 5.0	67.9 ± 27.3	25.0 ± 3.1	7.9 ± 2.1	110.0 ± 42.1	5.1 ± 0.9	/
Tu et al. 2024[33]	Retrospective	BLVP (Single-arm)	20	71.10 ± 7.06	61.50 ± 10.89	26.55 ± 1.88	7.40 ± 1.05	73.50 ± 12.26	4.55 ± 1.19	/
Man et al. 2023[34]	Retrospective	BLVP (Single-arm)	20	58.5 ± 3.7	52.1 ± 10.9	20.1 ± 2.3	8.1 ± 1.2	46.8 ± 12.7	4.9 ± 0.7	16.7 ± 1.9
Fan et al. 2023[35]	Retrospective	BLVP (Single-arm)	100	73.3 ± 7.7	66.6 ± 31.5	25.4 ± 4.0	7.0 ± 2.0	107.3 ± 122.4	5.0 ± 0.7	/
Hao et al. 2023[36]	Retrospective	BLVP (Single-arm)	30	62.3 ± 3.0	53.2 ± 4	25.1 ± 1.6	10.6 ± 3.5	57.3 ± 3.2	5.4 ± 0.7	/
Hu et al. 2025[37]	Prospective	BLVP (Single-arm)	67	63.91 ± 6.85	45.46 ± 26.25	24 (20, 26)	8.00 ± 2.00	42.0 (29.0, 55.5)	5 (4, 5)	18.0 (14.0, 19.0)
Wang et al. 2025[38]	Prospective	BLVP (Single-arm)	157	83.97 ± 3.63	63.4 ± 34.9	/	/	/	/	/
Zhang et al. 2025[14]	Retrospective	Bipolar TURP	46	73.59 ± 1.28	68.44 ± 1.72	29.13 ± 1.24	8.54 ± 0.87	/	/	/
		BLVP	52	73.61 ± 1.23	68.42 ± 1.75	29.16 ± 1.21	8.53 ± 0.85	/	/	/
Qiu et al. 2025[15]	Retrospective	Bipolar TURP	42	64.12 ± 2.14	58.35 ± 2.21	23.53 ± 2.21	8.25 ± 2.21	64.62 ± 3.46	5.16 ± 0.12	18.64 ± 1.15
		BLVP	43	63.98 ± 2.13	58.41 ± 2.23	23.48 ± 2.23	8.24 ± 2.23	64.58 ± 3.48	5.15 ± 0.14	18.72 ± 1.13
Chen et al. 2025[16]	Retrospective	Bipolar TURP	30	73.00 ± 6.06	58.17 ± 18.59	26.37 ± 4.90	5.59 ± 2.14	65.5 (39.5, 85.0)	5.17 ± 1.12	/
		BLVP	32	76.34 ± 7.97	55.43 ± 18.57	27.50 ± 4.50	6.12 ± 2.66	57.0 (32.5, 81.0)	5.44 ± 0.72	/
Xu et al. 2024[17]	Retrospective	Bipolar TURP	45	64.54 ± 3.23	65.22 ± 3.50	28.09 ± 2.01	8.43 ± 1.84	65.73 ± 1.05	4.78 ± 0.87	19.67 ± 1.77
		BLVP	46	65.22 ± 3.50	58.60 ± 2.40	28.02 ± 1.76	8.36 ± 1.78	65.29 ± 9.47	4.63 ± 0.79	19.74 ± 1.80
Zhang et al. 2024[39]	Retrospective	Monopolar TURP	30	83.36 ± 3.06	58.16 ± 2.03	23.88 ± 2.97	6.07 ± 2.31	124.58 ± 35.26	/	/
		BLVP	30	83.12 ± 2.88	56.23 ± 3.27	24.58 ± 3.26	5.97 ± 2.32	147.31 ± 30.37	/	/
Tu et al. 2024[40]	Retrospective	Monopolar TURP	70	61.67 ± 2.39	50.32 ± 8.17	26.89 ± 2.06	8.33 ± 1.78	69.73 ± 11.15	5 (5, 6)	19.47 ± 1.85
		BLVP	72	61.99 ± 2.58	50.32 ± 8.17	27.17 ± 1.98	8.36 ± 1.78	66.88 ± 9.67	5 (5, 6)	19.64 ± 1.64
Li et al. 2024[41]	Retrospective	Monopolar TURP	20	70.80 ± 6.96	52.91 ± 34.11	18.45 ± 3.50	/	/	4.60 ± 1.19	/
		BLVP	19	69.95 ± 9.21	63.97 ± 27.26	20.16 ± 3.45	/	/	4.32 ± 1.06	/

(Continued)

TABLE 1. **Continued**

Study	Design	Group	Sample size	Age (years)	Mean prostate volume (mL)	Preoperative IPSS (score)	Preoperative Q_{max} (mL/s)	Preoperative PVR (mL)	Preoperative QoL (score)	Preoperative IIEF-5 (score)
Liu et al. 2024[42]	Retrospective	Monopolar TURP	68	60.19 ± 6.58	/	17.98 ± 1.46	/	63.27 ± 7.74	/	6.24 ± 1.58
		BLVP	71	58.72 ± 6.31	/	17.62 ± 1.27	/	62.91 ± 8.06	/	5.96 ± 1.32
Zhang et al. 2024[43]	Prospective	Monopolar TURP	40	77.36 ± 3.07	59.16 ± 2.33	21.88 ± 2.92	6.05 ± 2.30	424.52 ± 35.00	/	/
		BLVP	40	77.12 ± 2.99	57.23 ± 3.29	20.58 ± 3.16	5.99 ± 2.22	450.31 ± 30.39	/	/
Wang et al. 2025[44]	Retrospective	1470 nm DiLEP	65	73.47 ± 3.06	74.47 ± 17.15	28.02 ± 3.81	7.17 ± 1.72	135.17 ± 50.40	4.24 ± 1.23	17.59 ± 4.96
		BLVP	63	74.38 ± 2.93	71.99 ± 18.72	26.97 ± 3.31	7.25 ± 1.20	118.90 ± 46.97	4.00 ± 1.40	18.18 ± 4.21
Gu et al. 2025[45]	Retrospective	GLVP (30–80 mL)	36	61.94 ± 4.70	55.02 ± 14.12	24.81 ± 4.10	9.22 ± 2.81	121.03 ± 41.18	4.75 ± 0.91	19.14 ± 1.64
		BLVP (30–80 mL)	30	63.23 ± 4.95	50.74 ± 10.58	24.93 ± 2.60	8.90 ± 3.06	129.23 ± 74.32	4.63 ± 0.61	19.57 ± 1.63
		GLVP (>80 mL)	15	65.07 ± 2.74	90.18 ± 10.30	27.60 ± 4.08	8.33 ± 3.02	132.67 ± 29.10	5.13 ± 0.83	17.53 ± 2.00
		BLVP (>80 mL)	16	63.25 ± 4.40	89.82 ± 7.29	28.50 ± 3.16	8.75 ± 3.02	115.81 ± 31.31	4.56 ± 0.96	17.00 ± 2.37

Note. IPSS, International Prostate Symptom Score; Q_{max}, Maximum Urinary Flow Rate; QoL, Quality of Life; PVR, Post-void Residual Volume; IIEF-5, International Index of Erectile Function-5; BLVP, 450 nm Blue Laser Vaporization of the Prostate; TURP, Transurethral Resection of the Prostate; GLVP, Greenlight Laser Vaporization of the Prostate; 1470 nm DiLEP, 1470 nm Diode Laser Enucleation of the Prostate.

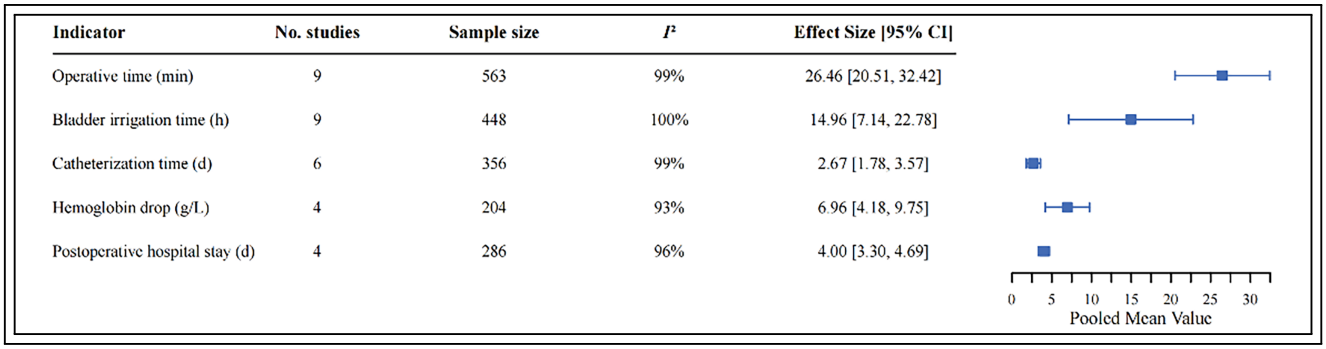

FIGURE 2. Results of single-arm meta-analysis of perioperative indicators of BLVP in the treatment of BPH. The blue square represents the pooled value, the horizontal line with whiskers indicates the confidence interval

CI: 7.74 to 15.73), 11.60 mL (95% CI: 4.88 to 18.32), and 14.92 mL (95% CI: 1.52 to 28.32), respectively. QoL continued to improve after the operation, and the mean score at 1 month after the operation was 2.32 (95% CI: 1.98 to 2.65). The mean score at 3 months was 1.97 (95% CI: 1.49 to 2.46). It was 1.82 at 6 months (95% CI: 1.50 to 2.14); The 12-month figure was 1.60 (95% CI: 1.03 to 2.17). Regarding sexual function, the mean score of IIEF-5 at 3 months was 13.80 (95% CI: 10.60 to 17.01). Notably, the wide confidence interval for the IIEF-5 at 6 months (crossing zero) suggests significant variability or limited sample size for this specific time point (11.74, 95% CI: −1.97 to 25.46).

The analysis of complications (Figure 4) showed that the overall complication rate of BLVP was relatively low. Low heterogeneity postoperative complications included (I^2 < 50%): capsular perforation (0%, 95% CI: 0% to 1%), urinary incontinence (1%, 95% CI: 0% to 2%), urinary retention (1%, 95% CI: 0% to 3%), urinary tract infection (2%, 95% CI: 1% to 5%),

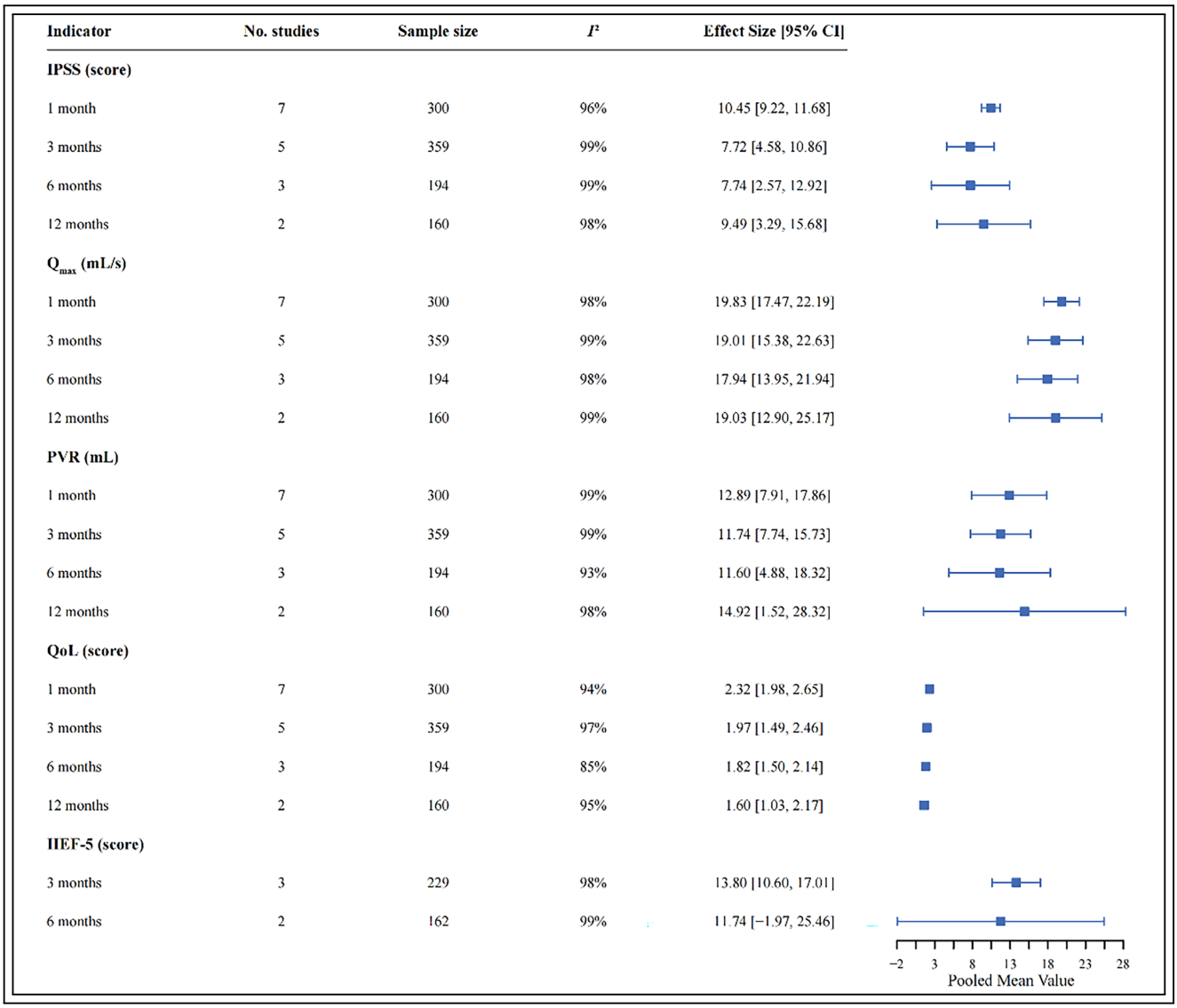

FIGURE 3. Results of single-arm meta-analysis of urination and sexual function indicators in the treatment of BPH. The blue square represents the pooled value, the horizontal line with whiskers indicates the confidence interval

secondary bleeding (1%, 95% CI: 0% to 3%), bladder neck contracture (0%, 95% CI: 0% to 2%), and bladder mucosal injury (0%, 95% CI: 0% to 4%). Some complications show high heterogeneity ($I^2 \geq 50\%$). The pooled incidence of urethral stricture and retrograde ejaculation was 2% (95% CI: 0% to 5%) and 0% (95% CI: 0% to 7%), respectively.

Tables A3–A5 show that, after subgroup analysis, the heterogeneity of IIEF-5 at 3 months, urethral stricture, and retrograde ejaculation was significantly reduced (I^2 decreased to 7%, 46%, and 0%, respectively), indicating that the difference in prostate volume was the main source of their heterogeneity. However, no substantial reduction in the heterogeneity of most outcomes was observed, indicating that prostate volume still cannot explain the source of the high heterogeneity of these indicators.

Comparison between BLVP and TURP

All 9 studies comparing BLVP with TURP were non-randomized intervention studies, with no RCTs. Among these, 5 studies compared BLVP with monopolar TURP, and 4 studies compared with bipolar TURP.

Complication	No. studies	Sample size	Events	I^2	Rate [95% CI]
Capsule perforation	5	214	0	0%	0% [0%, 1%]
Bladder mucosal injury	4	182	2	41%	0% [0%, 4%]
Urinary incontinence	7	380	5	0%	1% [0%, 2%]
Urinary retention	6	350	7	3%	1% [0%, 3%]
Urinary tract infection	4	278	9	0%	2% [1%, 5%]
Secondary bleeding	7	276	5	0%	1% [0%, 3%]
Bladder neck contracture	3	198	1	0%	0% [0%, 2%]
Urethral stricture	7	384	10	61%	2% [0%, 5%]
Retrograde ejaculation	3	128	1	53%	0% [0%, 7%]

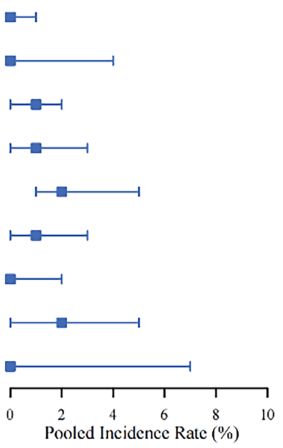

FIGURE 4. Results of single-arm meta-analysis of the complication rate of BLVP in the treatment of BPH. The blue square represents the pooled value, the horizontal line with whiskers indicates the confidence interval

Indicator	No. studies	Sample size (T/C)	I^2	MD [95% CI]
Operative time (min)	9	405/391	98%	−22.49 [−28.10, −16.87]
Bladder irrigation time (h)	8	353/345	100%	−21.63 [−33.11, −10.15]
Catheterization time (d)	8	333/321	100%	−2.21 [−3.20, −1.22]
Hemoglobin drop (g/L)	5	193/190	98%	−10.05 [−14.40, −5.69]
Hospital stay (d)	6	316/301	94%	−3.47 [−4.04, −2.90]

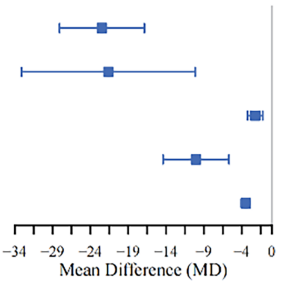

FIGURE 5. Comparison of perioperative indicators of BPH treated by BLVP and TURP. T, BLVP group; C, TURP group; The blue square represents the pooled value, the horizontal line with whiskers indicates the confidence interval, and the grey vertical line denotes the line of no effect

The results of the meta-analysis showed that BLVP was associated with shorter or reduced operative time (MD = −22.49 min, 95% CI: −28.10 to −16.87, $p < 0.001$), bladder irrigation time (MD = −21.63 h, 95% CI: −33.11 to −10.15, $p < 0.001$), catheterization time (MD = −2.21 days, 95% CI: −3.20 to −1.22, $p < 0.001$), hemoglobin drop (MD = −10.05 g/L, 95% CI: −14.40 to −5.69, $p < 0.001$) and hospital stay (MD = −3.47 days, 95% CI: −4.04 to −2.90, $p < 0.001$) compared to TURP (Figure 5). All perioperative indicators showed high heterogeneity ($I^2 \geq 50\%$).

In terms of indicators related to urinary function (Figure 6), there were no significant differences between BLVP and TURP in IPSS, Q_{max}, PVR at 3 and 6 months, and QoL score at 6 months after surgery (all $p \geq 0.05$). Except for the IPSS ($I^2 = 96\%$) at 3 months after the operation which showed high heterogeneity, the heterogeneity of the other indicators related to urinary function (Q_{max}, PVR, QoL) was low ($I^2 < 50\%$). Furthermore, regarding sexual function, the IIEF-5 of the BLVP group at 6 months was better than that of the TURP group (MD = 1.68, 95% CI: 1.08 to 2.28, $p < 0.001$), while this outcome was reported in only a limited number of studies, and it also shows high heterogeneity ($I^2 = 59\%$). In terms of complications (Figure 7), patients who received BLVP had significantly lower incidences of urinary incontinence (OR = 0.38, 95% CI: 0.16 to 0.87, $p = 0.023$), secondary bleeding (OR = 0.15, 95% CI: 0.03 to 0.70, $p = 0.015$), and retrograde ejaculation (OR = 0.07, 95% CI: 0.02 to 0.21, $p < 0.001$) than those who underwent TURP. There was no statistically significant difference in

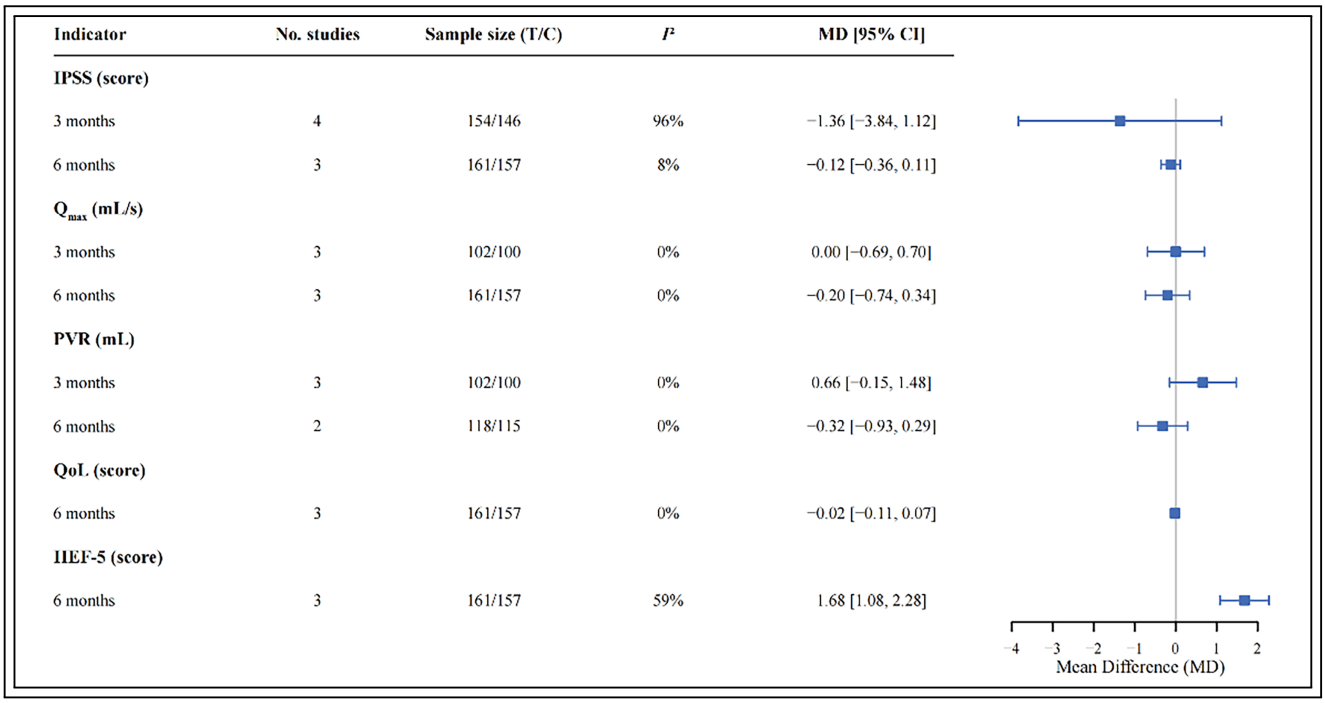

FIGURE 6. Comparison of urination and sexual function between BLVP and TURP in the treatment of BPH. T, BLVP group; C, TURP group; The blue square represents the pooled value, the horizontal line with whiskers indicates the confidence interval, and the grey vertical line denotes the line of no effect

the incidence of capsular perforation, urinary retention, urinary tract infection, bladder neck contracture and urethral stricture between the two groups (all $p \geq 0.05$). The heterogeneity of all complications was low ($I^2 \leq 50\%$).

The results of subgroup analysis indicated that in terms of perioperative indicators, the BLVP group demonstrated favorable profiles compared with both monopolar TURP and bipolar TURP. The operative time, bladder irrigation time, catheterization time and hospital stay were all significantly shortened. However, the advantage of BLVP in terms of hemoglobin drop was only statistically significant when compared with monopolar TURP (MD = −8.84 g/L, 95%CI −14.47 to −3.21, $p = 0.002$) (Table A6). In terms of indicators related to urinary function, the subgroup analysis results were consistent with the overall conclusion. The efficacy of the two surgeries in indicators such as IPSS, Q_{max}, PVR, and QoL was similar (all $p \geq 0.05$) (Table A7). However, the advantages of BLVP were obvious when compared with monopolar TURP, especially in urinary incontinence and secondary bleeding (Table A8). Regarding sexual function, the advantage in IIEF-5 was more pronounced when compared with bipolar TURP at 6 months. After subgroup analysis, except for IIEF-5 at 6 months (I^2 decreased to 36%), no significant reduction in heterogeneity was observed in the remaining indicators, suggesting that heterogeneity may stem from factors other than the TURP energy platform.

Comparison of BLVP with other transurethral laser surgeries

Ultimately, two retrospective cohort studies were included, comparing BLVP with 1470 nm DiLEP and GLVP, respectively.

In comparison with 1470 nm DiLEP, the BLVP group had shorter operative time and bladder irrigation time, indicating that it had higher tissue vaporization efficiency and faster postoperative recovery. The two groups were generally similar in terms of indicators related to urination and sexual function and the incidence of complications. However, due to the essential difference in tissue removal between vaporization and enucleation, the enucleation group had a greater advantage in improving Q_{max} at 3 months, indicating that more thorough removal of prostate tissue may lead to better urodynamic results.

In the comparative study with GLVP, patients were divided into the normal volume group (30–80 mL) and the large volume group (>80 mL)

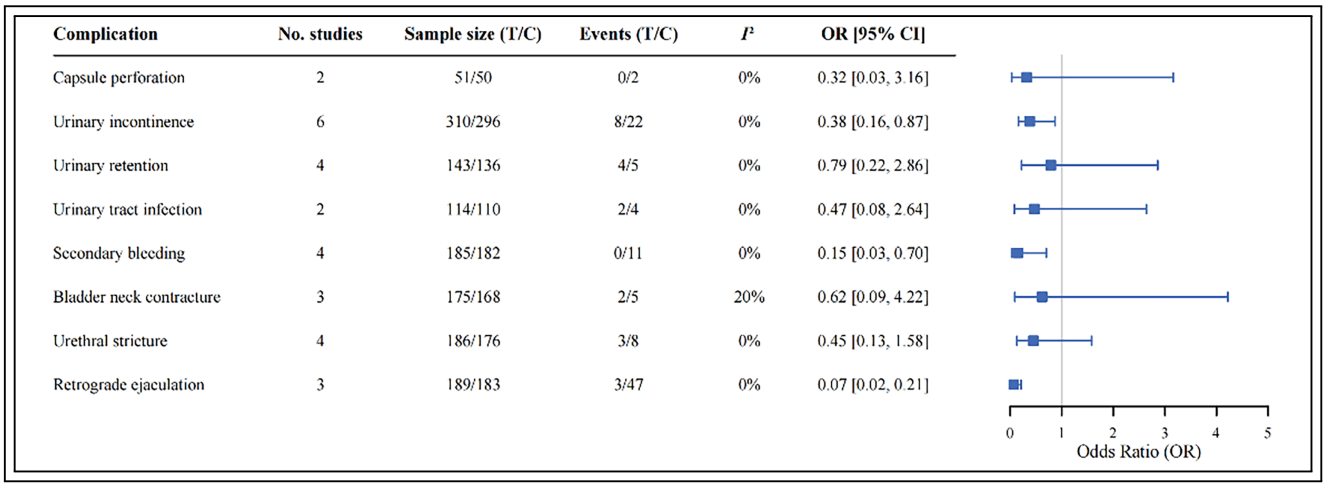

FIGURE 7. Comparison of the complication rates of BPH treated with BLVP and TURP. T, BLVP group; C, TURP group; The blue square represents the pooled value, the horizontal line with whiskers indicates the confidence interval, and the grey vertical line denotes the line of no effect

according to the prostate volume. The results showed that the BLVP group was superior to the GLVP group in terms of postoperative recovery indicators (including bladder irrigation time, catheterization time and postoperative hospital stay) for patients with normal volume. However, due to the sample size (n = 31), no significant differences were observed between the two surgeries in the large volume group. Among the subjective outcome measures (IPSS, QoL and IIEF-5), BLVP performed better, which might be attributed to its shallower tissue penetration and less thermal damage, thereby alleviating postoperative urinary tract irritation symptoms. However, in terms of objective indicators (Q_{max}, PVR), BLVP only demonstrated an advantage in PVR at 6 months in the normal volume group. In addition, both laser energy platform vaporization procedures are equally safe in terms of complications.

Discussion

As BPH is a common disease among middle-aged and elderly men, its surgical procedures are constantly being improved. For decades, TURP has been regarded as the "gold standard" in surgical treatment, yet its risks such as bleeding and urethral stricture still cannot be ignored.[18,19] Although emerging laser surgeries such as HoLEP and GLVP have addressed the shortcomings of TURP in some aspects, they also have disadvantages, such as a steep learning curve or limited vaporization efficiency. Our study conducts a comprehensive assessment of the safety and efficacy of BLVP in the treatment of BPH based on existing evidence.

Our single-arm meta-analysis indicates that BLVP demonstrated favorable outcomes across all perioperative indicators. We observed a mean operative time of 26.46 min, bladder irrigation time of 14.96 h, catheterization time of 2.67 days, and a mean decrease of 6.96 g/L in hemoglobin. The IPSS, Q_{max}, PVR and QoL scores at each follow-up time point (1, 3, 6 and 12 months) were improved compared with those before the operation. In terms of safety, the complication rate of BLVP was extremely low, and the pooled rate of multiple serious complications (such as capsular perforation and bladder mucosal injury) was close to 0%. The pooled rates of urinary incontinence and urinary retention were only 1%. These data preliminarily support the safety of BLVP as a minimally invasive surgery.

The comparison with TURP shows that BLVP has an advantage in all key perioperative indicators. Specifically, the operative time, bladder irrigation time, catheterization time and hospital stay were significantly shortened, while the decrease in hemoglobin was less. In terms of indicators related to urinary function (IPSS, Q_{max}, PVR, QoL), the efficacy of BLVP and TURP was similar in the medium and short term (3 and 6 months after surgery). In terms of safety, the advantages of BLVP are even more prominent. The incidences of urinary incontinence (OR = 0.38) and secondary bleeding (OR = 0.15) in the BLVP group were significantly lower than those in the TURP group. Although the number of studies reporting these outcomes is limited, it

is worth noting that BLVP showed preliminary potential in preserving sexual function. The incidence of retrograde ejaculation in patients treated with BLVP was reduced (OR = 0.07), and the IIEF-5 score at 6 months postoperative was better (MD = 1.68). Preliminary comparisons with GLVP suggest that BLVP may offer advantages in postoperative recovery (bladder irrigation, catheterization time) in patients with medium-volume prostate, and the improvement of subjective symptoms was better.

The observed clinical benefits, such as reduced bleeding and preservation of sexual function, align with the hypothesized physical properties of the 450 nm wavelength. Recent studies on wavelength-dependent laser-tissue interactions suggest that the high absorption coefficient of hemoglobin for blue light allows for superficial energy deposition. This theoretical property likely leads to a shallow coagulation zone, minimizing deep thermal injury to surrounding tissues.[12,13] Such precision not only facilitates the preservation of the neurovascular bundles, reducing the risk of erectile dysfunction, but also protects the bladder neck sphincter, consequently lowering the incidence of retrograde ejaculation. Furthermore, the shallow coagulation zone limits the volume of postoperative necrotic tissue and subsequent sloughing, which likely represents the fundamental reason for the improved subjective patient experience and accelerated tissue healing.[12,13,46,47]

In addition to the direct physical advantages of the 450 nm wavelength, the clinical applicability of BLVP in complex or high-risk patient groups also deserves further attention. As BPH mainly affects elderly men, this group often has cardiovascular comorbidities and requires continuous antiplatelet or anticoagulant therapy.[48] The excellent hemostatic effect of the blue laser indicates that BLVP may be the best surgical approach for these patients with high bleeding risks.[43,49] This characteristic may reduce the need for transition or discontinuation of anticoagulant drugs, thereby minimizing perioperative cardiovascular events.[49] Moreover, for physically frail patients, performing large-volume prostate surgery often poses challenges as it requires a longer anesthesia time. The rapid tissue vaporization achieved by the 450 nm laser helps to control the surgery time within a safer range, thereby reducing the occurrence of complications.[45]

Limitations

This study still has certain limitations. First, a substantial portion of our results relies on single-arm meta-analyses. As the vast majority of included studies only provided preoperative and postoperative absolute values without reporting the standard deviations for changes, we were restricted to pooling absolute postoperative values rather than within-study changes. Consequently, we acknowledge that these pooled estimates primarily reflect postoperative status rather than definitive evidence of a treatment effect. Furthermore, the lack of a direct control group means that the significant improvements observed in subjective outcomes (such as IPSS and QoL) could be partially attributed to the placebo effect or regression to the mean. Second, all comparative analyses in this study are based on non-randomized studies without adequate control for confounding variables. As a result, the reported MDs between BLVP and comparator procedures are susceptible to selection bias. Thus, the certainty of the evidence should be regarded as low-to-moderate. Third, substantial statistical heterogeneity persisted across most pooled outcomes. Although we conducted subgroup analyses, the limited number of studies and available data precluded the use of robust meta-regression to adequately explore the sources of this variability. This unexplained heterogeneity likely stems from unmeasured clinical variables, including variations in surgeon experience, differences in laser power settings, diverse perioperative management protocols, and baseline prostate morphology, which limits the interpretability and generalizability of the pooled estimates. Fourth, the short follow-up periods of existing studies preclude definitive conclusions regarding long-term efficacy, re-operation rates, and long-term complications. Fifth, due to the small sample size of some subgroup analyses and the limitations of statistical power, the risk of type II errors has increased. Finally, as the findings are primarily derived from Chinese populations, further multi-regional validation and future rigorous RCTs are required to ensure generalizability across diverse anatomical and clinical profiles and to confirm our preliminary findings.

Conclusions

Preliminary evidence suggests that BLVP is a potentially safe and effective surgical option for BPH, demonstrating favorable trends in postoperative recovery and sexual function preservation. However, the overall certainty of the evidence remains low-to-moderate. Due to the lack of high-quality RCTs, the equivalence or superiority of BLVP relative to conventional standards such as TURP cannot be definitively

established. Further large-scale RCTs are warranted to evaluate its long-term efficacy and safety.

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Author Contributions

Ren-Peng Yu: Conceptualization, Methodology, Formal analysis, Visualization, Software, Writing—original draft. Ou-Yang Song: Formal analysis. Hong Weng: Methodology, Formal analysis. Yong-Bo Wang: Methodology, Formal analysis. Bing-Hui Li: Data curation. Hao Zi: Data curation, Visualization. Yu Hao: Data curation, Visualization. Qiang Li: Project administration, Resources, Supervision. Xian-Tao Zeng: Conceptualization, Writing—review and editing, Project administration, Resources, Supervision. All authors reviewed and approved the final version of the manuscript.

Availability of Data and Materials

All data are publicly accessible.

Ethics Approval

Ethical approval was not required for this meta-analysis as it utilized exclusively publicly available and previously published data.

Conflicts of Interest

The authors declare no conflicts of interest.

Supplementary Materials:

The supplementary material is available online at https://www.techscience.com/doi/10.32604/cju.2026.079426/s1.

Appendix A

TABLE A1. **Risk of bias and quality assessment for single-arm clinical trials**

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
Xu et al. 2025[27]	Y	Y	Y	CD	NR	Y	Y	NR	Y	Y	Y	Y
Cao et al. 2025[28]	Y	Y	Y	CD	NR	N	Y	NR	N	Y	Y	Y
Yao et al. 2024[29]	Y	Y	Y	CD	NR	Y	Y	NR	Y	Y	Y	Y
Zhang et al. 2024[30]	Y	Y	Y	CD	NR	Y	Y	NR	Y	Y	N	Y
Tu et al. 2024[31]	Y	Y	Y	CD	NR	Y	Y	NR	Y	Y	N	Y
Wang et al. 2024[32]	Y	Y	Y	CD	NR	Y	Y	NR	Y	Y	N	Y
Tu et al. 2024[33]	Y	Y	Y	CD	NR	Y	Y	NR	Y	Y	N	Y
Man et al. 2023[34]	Y	Y	Y	CD	NR	Y	Y	NR	Y	Y	N	Y
Fan et al. 2023[35]	Y	Y	Y	CD	NR	Y	Y	NR	Y	Y	N	Y
Hao et al. 2023[36]	Y	Y	Y	CD	NR	Y	Y	NR	Y	Y	Y	Y
Hu et al. 2025[37]	Y	Y	Y	Y	NR	Y	Y	NR	Y	Y	N	Y
Wang et al. 2025[38]	Y	Y	Y	Y	NR	Y	Y	NR	Y	Y	N	Y

Note. NIH tool for pre-post studies with no control group; Q1, objective clearly stated; Q2, eligibility criteria described; Q3, representative patient population; Q4, all eligible participants enrolled in study; Q5, sufficient sample size; Q6, intervention described; Q7, outcome measures specified; Q8, outcome assessors blinded; Q9, loss to follow-up less than 20%; Q10, statistical analysis of outcome; Q11, interrupted time-series design; Q12, individual data used for group-level effects; Y, Yes; N, No; CD, cannot determine; NR, not reported.

TABLE A2. **Risk of bias and quality assessment for non-randomized studies of interventions**

Study	D1	D2	D3	D4	D5	D6	D7	Overall
Zhang et al. 2025[14]	Moderate	Low	Low	Low	Low	Moderate	Moderate	Moderate
Qiu et al. 2025[15]	Moderate	Low	Low	Low	Low	Moderate	Moderate	Moderate
Chen et al. 2025[16]	Low	Low	Low	Low	Low	Moderate	Moderate	Moderate
Xu et al. 2024[17]	Moderate	Low	Low	Low	Low	Moderate	Moderate	Moderate
Zhang et al. 2024[39]	Low	Low	Low	Low	Low	Moderate	Moderate	Moderate
Tu et al. 2024[40]	Moderate	Low	Low	Low	Low	Moderate	Moderate	Moderate
Li et al. 2024[41]	Moderate	Low	Low	Low	Low	Moderate	Serious	Serious
Liu et al. 2024[42]	Serious	Moderate	Low	Low	Low	Moderate	Moderate	Serious
Zhang et al. 2024[43]	Low	Low	Low	Low	Low	Moderate	Moderate	Moderate
Wang et al. 2025[44]	Moderate	Low	Low	Low	Low	Moderate	Moderate	Moderate
Gu et al. 2025[45]	Low	Low	Low	Low	Low	Moderate	Moderate	Moderate

Note. ROBINS-I tool for non-randomized studies of interventions; D1, bias due to confounding; D2, bias in selection of participants into the study; D3, bias due in classification of interventions; D4, bias due to deviations from intended interventions; D5, bias due to missing data; D6, bias in measurement of outcomes; D7, bias in selection of the reported result.

TABLE A3. **Subgroup analysis of perioperative indicators based on prostate volume in a single-arm meta-analysis**

Outcomes or subgroups*	No. studies	Sample size	Heterogeneity		Effect size [95% CI]
			I^2	*p*-value	
Operative time (min)					
Small volume	1	34	NA	NA	12.60 [11.69, 13.51]
Mixed volume	8	529	99%	<0.001	28.27 [21.33, 35.22]
Bladder irrigation time (h)					
Small volume	1	30	NA	NA	5.27 [3.92, 6.62]
Mixed volume	7	384	100%	<0.001	15.58 [6.57, 24.60]
Large volume	1	34	NA	NA	20.27 [19.35, 21.19]
Catheterization time (d)					
Small volume	1	34	NA	NA	1.33 [0.81, 1.85]
Mixed volume	5	322	99%	<0.001	2.93 [1.96, 3.90]
Hemoglobin drop (g/L)					
Small volume	1	34	NA	NA	7.01 [3.51, 10.51]
Mixed volume	3	170	96%	<0.001	6.80 [4.59, 9.01]
Postoperative hospital stay (d)					
Small volume	1	34	NA	NA	5.67 [4.89, 6.45]
Mixed volume	3	252	96%	<0.001	3.57 [2.93, 4.21]

Note. *A subgroup is not displayed if it is reported by fewer than one study; NA, not applicable.

TABLE A4. **Subgroup analysis of urination and sexual function indicators based on prostate volume in a single-arm meta-analysis**

Outcomes or subgroups*	No. studies	Sample size	Heterogeneity		Effect Size [95% CI]
			I^2	*p*-value	
IPSS at 1 month (score)					
Mixed volume	6	270	96%	<0.001	10.80 [9.41, 12.19]
Large volume	1	30	NA	NA	8.47 [7.96, 8.98]
IPSS at 3 months (score)					
Small volume	1	34	NA	NA	3.60 [2.74, 4.46]
Mixed volume	4	325	99%	<0.001	8.75 [5.51, 11.98]
IPSS at 6 months (score)					
Small volume	1	34	NA	NA	2.77 [1.65, 3.89]
Mixed volume	2	160	99%	<0.001	10.21 [3.01, 17.41]
IPSS at 12 months (score)					
Mixed volume	2	160	98%	<0.001	9.49 [3.29, 15.68]
Q_{max} at 1 month (mL/s)					
Mixed volume	7	270	98%	<0.001	19.87 [17.03, 22.71]
Large volume	1	30	NA	NA	19.60 [18.78, 20.42]
Q_{max} at 3 months (mL/s)					
Small volume	1	34	NA	NA	15.70 [14.53, 16.87]
Mixed volume	4	325	99%	<0.001	19.83 [15.57, 24.08]
Q_{max} at 6 months (mL/s)					
Small volume	1	34	NA	NA	15.67 [14.89, 16.45]
Mixed volume	2	160	98%	<0.001	19.09 [14.46, 23.72]
Q_{max} at 12 months (mL/s)					
Mixed volume	2	160	99%	<0.001	19.03 [12.90, 25.17]
PVR at 1 month (mL)					
Mixed volume	6	270	99%	<0.001	13.36 [7.72, 19.00]
Large volume	1	30	NA	NA	10.17 [7.99, 12.35]
PVR at 3 months (mL)					
Small volume	1	34	NA	NA	10.00 [4.80, 15.20]
Mixed volume	4	325	99%	<0.001	12.07 [7.67, 16.46]
PVR at 6 months (mL)					
Small volume	1	34	NA	NA	6.10 [2.12, 10.08]
Mixed volume	2	160	96%	<0.001	14.47 [2.51, 26.44]
PVR at 12 months (mL)					
Mixed volume	2	160	98%	<0.001	14.92 [1.52, 28.32]
QoL at 1 month (score)					
Mixed volume	6	270	90%	<0.001	2.46 [2.17, 2.74]
Large volume	1	30	NA	NA	1.50 [1.22, 1.78]
QoL at 3 months (score)					
Small volume	1	34	NA	NA	1.67 [1.41, 1.93]
Mixed volume	4	325	97%	<0.001	2.05 [1.48, 2.62]
QoL at 6 months (score)					
Small volume	1	34	NA	NA	1.67 [1.41, 1.93]
Mixed volume	2	160	93%	<0.001	1.90 [1.36, 2.45]
QoL at 12 months (score)					
Mixed volume	2	160	95%	<0.001	1.60 [1.03, 2.17]
IIEF-5 at 3 months (score)					
Small volume	1	34	NA	NA	4.83 [2.10, 7.56]
Mixed volume	2	195	7%	0.301	17.56 [17.24, 17.88]
IIEF-5 at 6 months (score)					
Small volume	1	34	NA	NA	4.67 [1.81, 7.53]
Mixed volume	1	128	NA	NA	18.67 [18.32, 19.02]

Note. *A subgroup is not displayed if it is reported by fewer than one study; NA, not applicable; IPSS, International Prostate Symptom Score; Q_{max}, Maximum Urinary Flow Rate; QoL, Quality of Life; PVR, Post-void Residual Volume; IIEF-5, International Index of Erectile Function-5.

TABLE A5. **Subgroup analysis of complication rates based on prostate volume in a single-arm meta-analysis**

Outcomes or subgroups*	No. studies	Sample size	Events	Heterogeneity		Rate [95% CI]
				I^2	*p*-value	
Capsule perforation						
Small volume	1	30	0	NA	NA	0% [0%, 6%]
Mixed volume	3	154	0	0%	0.855	0% [0%, 1%]
Large volume	1	30	0	NA	NA	0% [0%, 6%]
Bladder mucosa injury						
Mixed volume	3	152	2	61%	0.078	1% [0%, 6%]
Large volume	1	30	0	NA	NA	0% [0%, 6%]
Urinary incontinence						
Mixed volume	6	350	5	0%	0.880	1% [0%, 2%]
Large volume	1	30	0	NA	NA	0% [0%, 6%]
Urinary retention						
Mixed volume	5	320	7	15%	0.319	1% [0%, 4%]
Large volume	1	30	0	NA	NA	0% [0%, 6%]
Urinary tract infection						
Mixed volume	3	248	9	0%	0.581	3% [1%, 6%]
Large volume	1	30	0	NA	NA	0% [0%, 6%]
Secondary bleeding						
Small volume	1	34	0	NA	NA	0% [0%, 5%]
Mixed volume	5	212	5	0%	0.761	2% [0%, 4%]
Large volume	1	30	0	NA	NA	0% [0%, 6%]
Bladder neck contracture						
Mixed volume	3	198	1	0%	0.948	0% [0%, 2%]
Urethral stricture						
Small volume	1	34	1	NA	NA	3% [0%, 12%]
Mixed volume	5	320	9	46%	0.083	2% [0%, 6%]
Large volume	1	30	0	NA	NA	0% [0%, 6%]
Retrograde ejaculation						
Small volume	1	8	1	NA	NA	12% [0%, 46%]
Mixed volume	2	120	0	0%	0.620	0% [0%, 1%]

Note. *A subgroup is not displayed if it is reported by fewer than one study; NA, not applicable.

TABLE A6. **Subgroup analysis of perioperative indicators based on the TURP energy platform in a comparative meta-analysis**

Outcomes or subgroups*	No. studies	Sample size (T/C)	Heterogeneity		Mean Difference [95% CI]	*p*-value
			I^2	*p*-value		
Operative time (min)						
vs. Monopolar TURP	4	232/228	97%	<0.001	−17.70 [−22.76, −12.64]	<0.001
vs. Bipolar TURP	5	173/163	98%	<0.001	−27.05 [−36.63, −17.48]	<0.001
Bladder irrigation time (h)						
vs. Monopolar TURP	5	232/228	100%	<0.001	−13.15 [−24.97, −1.32]	<0.001
vs. Bipolar TURP	3	121/117	83%	0.003	−33.56 [−36.62, −30.50]	<0.001
Catheterization time (d)						
vs. Monopolar TURP	4	160/158	99%	<0.001	−1.02 [−1.95, −0.08]	0.033
vs. Bipolar TURP	4	173/163	97%	<0.001	−3.34 [−4.05, −2.63]	<0.001
Hemoglobin drop (g/L)						
vs. Monopolar TURP	3	121/120	94%	<0.001	−8.84 [−14.47, −3.21]	0.002
vs. Bipolar TURP	2	72/70	99%	<0.001	−11.76 [−23.57, 0.06]	0.051
Hospital stay (d)						
vs. Monopolar TURP	2	143/138	93%	<0.001	−2.76 [−4.63, −0.89]	0.004
vs. Bipolar TURP	4	173/163	95%	<0.001	−3.78 [−4.72, −2.83]	<0.001

Note. *A subgroup is not displayed if it is reported by fewer than one study; T, 450 nm Blue Laser Vaporization of the Prostate; C, Transurethral Resection of the Prostate

TABLE A7. **Subgroup analysis of urination and sexual function based on the TURP energy platform in a comparative meta-analysis**

Outcomes or subgroups*	No. studies	Sample size (T/C)	Heterogeneity		Mean Difference [95% CI]	*p*-value
			I^2	*p*-value		
IPSS at 3 months (score)						
vs. Monopolar TURP	2	70/70	0%	0.938	−0.16 [−1.02, 0.71]	0.720
vs. Bipolar TURP	2	84/76	97%	<0.001	−2.53 [−5.81, 0.76]	0.131
IPSS at 6 months (score)						
vs. Monopolar TURP	1	72/70	NA	NA	−0.20 [−0.86, 0.46]	NA
vs. Bipolar TURP	2	89/87	53%	0.143	0.12 [−0.75, 1.00]	0.780
Q_{max} at 3 months (mL/s)						
vs. Monopolar TURP	2	70/70	0%	0.843	0.10 [−0.64, 0.84]	0.794
vs. Bipolar TURP	1	32/30	NA	NA	−0.68 [−2.65, 1.29]	NA
Q_{max} at 6 months (mL/s)						
vs. Monopolar TURP	1	72/70	NA	NA	0.02 [−0.73, 0.77]	NA
vs. Bipolar TURP	2	89/87	0%	0.406	−0.45 [−1.23, 0.33]	0.258
PVR at 3 months (mL)						
vs. Monopolar TURP	2	70/70	0%	0.518	0.84 [−0.06, 1.74]	0.068
vs. Bipolar TURP	1	32/30	NA	NA	−0.17 [−2.13, 1.79]	NA
PVR at 6 months (mL)						
vs. Monopolar TURP	1	72/70	NA	NA	−0.38 [−1.17, 0.41]	NA
vs. Bipolar TURP	1	46/45	NA	NA	−0.23 [−1.18, 0.72]	NA
QoL at 6 months (score)						
vs. Monopolar TURP	1	72/70	NA	NA	0.00 [−0.25, 0.25]	NA
vs. Bipolar TURP	2	89/87	0%	0.641	−0.03 [−0.12, 0.07]	0.597
IIEF-5 at 6 months (score)						
vs. Monopolar TURP	1	72/70	NA	NA	1.13 [0.47, 1.79]	NA
vs. Bipolar TURP	2	89/87	36%	0.211	1.93 [1.33, 2.53]	<0.001

Note. *A subgroup is not displayed if it is reported by fewer than one study; NA, not applicable; IPSS, International Prostate Symptom Score; Q_{max}, Maximum Urinary Flow Rate; QoL, Quality of Life; PVR, Post-void Residual Volume; IIEF-5, International Index of Erectile Function-5; T, 450 nm Blue Laser Vaporization of the Prostate; C, Transurethral Resection of the Prostate

TABLE A8. **Subgroup analysis of complication rates based on the TURP energy platform in a comparative meta-analysis**

Outcomes or subgroups*	No. studies	No.studies (T/C)	Events (T/C)	Heterogeneity		Odds ratio [95% CI]	*p*-value
				I^2	*p*-value		
Capsule perforation	2	51/50	0/2	0%	0.967	0.32 [0.03, 3.16]	0.328
vs. Monopolar TURP	1	19/20	0/1	NA	NA	0.33 [0.01, 8.70]	NA
vs. Bipolar TURP	1	32/30	0/1	NA	NA	0.30 [0.01, 7.72]	NA
Urinary incontinence	6	310/296	8/22	0%	0.831	0.38 [0.16, 0.87]	0.023
vs. Monopolar TURP	3	183/178	3/13	0%	0.631	0.26 [0.08, 0.89]	0.032
vs. Bipolar TURP	3	127/118	5/9	0%	0.773	0.52 [0.17, 1.62]	0.261
Urinary retention	4	143/136	4/5	0%	0.730	0.79 [0.22, 2.86]	0.716
vs. Monopolar TURP	2	59/60	2/2	0%	0.355	0.97 [0.14, 6.86]	0.976
vs. Bipolar TURP	2	84/76	2/3	0%	0.545	0.67 [0.12, 3.72]	0.647
Urinary tract infection	2	114/110	2/4	0%	0.995	0.47 [0.08, 2.64]	0.395
vs. Monopolar TURP	1	71/68	1/2	NA	NA	0.47 [0.04, 5.32]	NA
vs. Bipolar TURP	1	43/42	1/2	NA	NA	0.48 [0.04, 5.46]	NA
Secondary bleeding	4	185/182	0/11	0%	0.934	0.15 [0.03, 0.70]	0.015
vs. Monopolar TURP	3	142/140	0/9	0%	0.816	0.14 [0.02, 0.82]	0.030
vs. Bipolar TURP	1	43/42	0/2	NA	NA	0.19 [0.01, 4.00]	NA
Bladder neck contracture	3	175/168	2/5	20%	0.287	0.62 [0.09, 4.22]	0.622
vs. Monopolar TURP	1	143/138	1/5	19%	0.267	2.90 [0.11, 74.10]	NA
vs. Bipolar TURP	2	32/30	1/0	NA	NA	0.33 [0.03, 3.10]	NA
Urethral stricture	4	186/176	3/8	0%	0.730	0.45 [0.13, 1.58]	0.212
vs. Monopolar TURP	2	102/100	2/4	0%	0.373	0.60 [0.11, 3.18]	0.546
vs. Bipolar TURP	2	84/76	1/4	0%	0.622	0.31 [0.05, 2.09]	0.228
Retrograde ejaculation	3	189/183	3/47	0%	0.445	0.07 [0.02, 0.21]	<0.001
vs. Monopolar TURP	2	143/138	1/31	30%	0.233	0.05 [0.01, 0.37]	0.004
vs. Bipolar TURP	1	46/45	2/16	NA	NA	0.08 [0.02, 0.39]	NA

Note. *A subgroup is not displayed if it is reported by fewer than one study; NA, not applicable; T, 450 nm Blue Laser Vaporization of the Prostate; C, Transurethral Resection of the Prostate

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