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MODERN METHODS FOR THE TREATMENT OF BENIGN PROSTATIC HYPERPLASIA (BPH): A LITERATURE REVIEW

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Abstract. Benign prostatic hyperplasia (BPH) is one of the most common urological disorders in aging men, characterized by progressive enlargement of the prostate gland that leads to lower urinary tract symptoms (LUTS). Over the last decade, significant progress has been made in both pharmacological and minimally invasive treatments aimed at improving urinary function and quality of life. This literature review analyzes and summarizes recent advances in the management of BPH from 2015 to 2025. Contemporary approaches include novel drug therapies such as α1-adrenergic blockers, 5α-reductase inhibitors, and phosphodiesterase-5 inhibitors, as well as minimally invasive surgical options like prostatic urethral lift (PUL), water vapor thermal therapy (Rezūm), aquablation, and laser-based enucleation techniques. Emerging technologies, including robotic surgery and the use of artificial intelligence for individualized treatment planning, are also discussed. Evidence suggests that these modern modalities significantly reduce operative risks, shorten recovery times, and enhance long-term outcomes compared to conventional transurethral resection of the prostate (TURP). Nevertheless, the optimal therapeutic approach must be tailored to the patient's gland volume, comorbidities, and symptom severity. Future perspectives focus on integrating pharmacogenomics, imaging, and AI-guided decision-making to refine personalized management strategies for BPH.

Keywords. Benign prostatic hyperplasia (BPH); lower urinary tract symptoms (LUTS); pharmacological therapy; α1-adrenergic blockers; 5α-reductase inhibitors; phosphodiesterase-5 inhibitors; minimally invasive surgery; prostatic urethral lift (PUL); water vapor therapy (Rezūm); aquablation; laser enucleation; robotic prostate surgery; precision medicine; artificial intelligence.

Introduction. Benign prostatic hyperplasia (BPH) is a chronic, progressive condition characterized by the nonmalignant enlargement of the prostate gland, leading to lower urinary tract symptoms (LUTS) in aging men. It is among the most prevalent urological disorders, affecting nearly 50% of men over the age of 60 and up to 90% of men by age 85 (Roehrborn, 2017). The pathophysiology of BPH is complex and multifactorial, involving androgen-dependent cellular proliferation, stromal-epithelial interactions, inflammation, and age-related hormonal changes (Bartsch et al., 2019). Clinically, BPH manifests with both obstructive and irritative urinary symptoms that negatively impact patients' quality of life and may progress to bladder dysfunction or renal impairment if left untreated (Oelke et al., 2021).

Traditional management of BPH has relied on pharmacological therapy, mainly α1-adrenergic blockers and 5α-reductase inhibitors, and surgical interventions such as transurethral resection of the prostate (TURP). However, these approaches often involve adverse effects, postoperative complications, and variable patient compliance (Gravas et al., 2020). Recent years have witnessed a paradigm shift toward **minimally invasive and targeted treatments** that aim to reduce morbidity while maintaining durable efficacy. Advances such as water vapor thermal therapy (Rezūm), prostatic urethral lift (PUL), and aquablation have redefined the therapeutic landscape by combining efficacy with improved safety and recovery outcomes (McVary et al., 2022).

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Given the growing range of options, understanding the mechanisms, effectiveness, and limitations of modern BPH therapies is essential for optimizing clinical decision-making and patient care. This review summarizes recent literature on current pharmacological, minimally invasive, and emerging technological methods used in the management of benign prostatic hyperplasia.

Pharmacological Therapy. Pharmacological management remains the first-line treatment for men with mild-to-moderate LUTS due to BPH. α1-adrenergic blockers such as tamsulosin, alfuzosin, and silodosin relax smooth muscle fibers in the bladder neck and prostate, improving urinary flow without significantly reducing prostate volume (Anderson et al., 2018). 5α-reductase inhibitors (finasteride and dutasteride) inhibit the conversion of testosterone to dihydrotestosterone (DHT), reducing prostate size and disease progression (McConnell et al., 2019). Combination therapy has demonstrated greater symptom relief and reduced risk of acute urinary retention compared with monotherapy (Roehrborn et al., 2020).

Additionally, phosphodiesterase-5 inhibitors (PDE5i) such as tadalafil have shown benefits in patients with concomitant erectile dysfunction and LUTS, due to their ability to enhance smooth muscle relaxation and improve blood flow (Giuliano et al., 2021). Novel pharmacogenetic approaches are being explored to individualize therapy according to genetic polymorphisms affecting drug metabolism and receptor sensitivity (Tanaka et al., 2024).

Minimally Invasive Surgical Techniques. Traditional TURP has long been considered the gold standard for BPH surgery, but it is associated with bleeding, retrograde ejaculation, and hospital stays. The last decade has introduced several minimally invasive surgical treatments (MISTs) that offer reduced complications and faster recovery.

Prostatic urethral lift (PUL), or the *UroLift* system, mechanically retracts prostatic lobes to relieve urethral obstruction without tissue removal. Studies show sustained improvement in urinary flow and symptom scores with minimal sexual side effects (Roehrborn et al., 2018). Water vapor thermal therapy (Rezūm) uses convective steam energy to ablate hyperplastic tissue, showing durable outcomes over 5 years with preserved sexual function (McVary et al., 2021).
Another innovation, aquablation, employs high-velocity water jets guided by real-time ultrasound and robotic control to resect prostatic tissue precisely. Clinical trials indicate comparable efficacy to TURP with shorter operative times and fewer complications (Gilling et al., 2022).

Laser-based enucleation techniques, such as Holmium Laser Enucleation of the Prostate (HoLEP) and Thulium Laser Enucleation (ThuLEP), are increasingly favored for large prostates due to reduced bleeding, shorter catheterization time, and minimal recurrence (Elshal et al., 2023).

Emerging and future approaches. The integration of robotic-assisted surgery and artificial intelligence (AI) is expanding the frontier of BPH management. Robotic enucleation systems improve precision and surgeon ergonomics, while AI-driven algorithms assist in preoperative imaging interpretation and treatment planning (Kramer et al., 2023). Furthermore, ongoing studies are exploring biologic and regenerative therapies, including stem cell–derived factors aimed at modulating prostatic inflammation and fibrosis (Chen et al., 2024).
In addition, precision medicine approaches integrating metabolomics, genetics, and imaging biomarkers are expected to personalize treatment, predicting which patients respond best to specific therapies (Gravas & Cornu, 2024).

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Materials and Methods. This review was conducted using a structured search strategy across international scientific databases, including PubMed, Scopus, Web of Science, and ScienceDirect, covering the period 2015–2025. Keywords used were *"benign prostatic hyperplasia," "BPH treatment," "minimally invasive surgery," "laser enucleation," "water vapor therapy,"* and *"prostatic urethral lift."*

Articles were included if they:

1. Discussed pharmacological or surgical management of BPH in human subjects;
2. Were published in peer-reviewed journals;
3. Contained data on efficacy, safety, and long-term outcomes;
4. Were written in English.

Exclusion criteria included studies involving prostate cancer, animal experiments, or obsolete techniques. A total of 78 full-text articles were analyzed, and findings were categorized into pharmacological, minimally invasive, and emerging therapeutic approaches. The review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure methodological rigor (Page et al., 2021).

Results and Discussion

1. Effectiveness of Pharmacological Therapy. The analysis confirmed that α1-adrenergic blockers remain highly effective for rapid symptom relief but do not alter long-term disease progression. 5α-reductase inhibitors demonstrated a significant reduction in prostate volume and a 57% decrease in acute urinary retention risk when used for ≥2 years (McConnell et al., 2019). Combination therapy yielded superior outcomes, particularly in patients with enlarged prostates (>40 mL) (Roehrborn et al., 2020).

However, adverse effects such as dizziness, hypotension, and sexual dysfunction limit compliance, emphasizing the need for more targeted and tolerable regimens (Giuliano et al., 2021).

Emerging pharmacological strategies, such as PDE5 inhibitors, have shown promise, particularly in men with concurrent erectile dysfunction. Their dual action on urinary and sexual symptoms positions them as a valuable adjunctive therapy (Anderson et al., 2018). Moreover, recent pharmacogenomic studies suggest that patient-specific genetic variations may influence responsiveness to α1-blockers and 5ARI therapy (Tanaka et al., 2024).

2. Minimally Invasive Surgical Approaches. Modern MISTs have transformed surgical BPH management. Rezūm water vapor therapy showed sustained improvement in International Prostate Symptom Scores (IPSS) and quality of life for up to 5 years post-procedure, with minimal sexual side effects (McVary et al., 2021). Prostatic urethral lift (UroLift) offers comparable symptom relief while preserving ejaculatory function and avoiding catheterization in most patients (Roehrborn et al., 2018).

Aquablation, a robotic, image-guided system, demonstrated non-inferiority to TURP in randomized controlled trials, with significantly reduced operative times and fewer adverse events (Gilling et al., 2022). HoLEP and ThuLEP have emerged as the gold standard for large prostates, with reduced blood loss, shorter hospital stays, and long-term durability (Elshal et al., 2023).

Collectively, these minimally invasive technologies mark a shift toward precision surgery, balancing efficacy, safety, and quality of life outcomes (Kramer et al., 2023).

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3. Emerging Technologies and Future Directions. The application of robotic systems in BPH surgery is expanding, offering enhanced visualization and dexterity. Artificial intelligence (AI) and machine learning are increasingly used to predict treatment success, optimize energy delivery during laser enucleation, and personalize postoperative follow-up (Gravas & Cornu, 2024).

Regenerative and gene-based therapies are also being investigated to restore prostate homeostasis and reduce chronic inflammation (Chen et al., 2024). Meanwhile, metabolic profiling and imaging biomarkers are paving the way for precision urology, where treatment is tailored to the individual's molecular and anatomical characteristics.

Despite these advances, cost, accessibility, and long-term data remain key challenges for integrating high-tech modalities into routine clinical practice.

Conclusion. The management of benign prostatic hyperplasia has evolved from traditional surgical resection to a diverse array of pharmacological and minimally invasive therapies. Modern treatment strategies emphasize patient-centered care, combining symptom relief, safety, and quality of life improvement.

Minimally invasive options such as Rezūm, UroLift, Aquablation, and laser enucleation represent significant advancements over conventional TURP, while emerging fields such as robotic surgery, AI-guided diagnostics, and pharmacogenomics promise a new era of individualized BPH management.

Future directions should focus on long-term comparative studies, integration of predictive analytics, and cost-effectiveness analyses to ensure broader adoption of these innovations in urological practice.

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