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Management of Benign Prostatic Hyperplasia and Problems of Transurethral Resection of the Prostate

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Abstract:

Background: Benign prostatic hyperplasia (BPH) is one of the most prevalent urological disorders affecting middle-aged and older men. It is characterized by non-malignant proliferation of prostatic stromal and epithelial tissues, which may lead to enlargement of the prostate, bladder outlet obstruction, and the development of lower urinary tract symptoms (LUTS). These symptoms commonly include urinary frequency, urgency, nocturia, hesitancy, weak or intermittent urinary stream, straining, incomplete bladder emptying, terminal dribbling, and urinary incontinence. The prevalence and severity of BPH increase markedly with age, making it an important cause of impaired quality of life, sleep disturbance, psychological distress, and reduced daily functioning among elderly men. If inadequately managed, BPH may result in serious complications such as acute urinary retention, recurrent urinary tract infection, bladder stones, hematuria, bladder decompensation, renal insufficiency, and deterioration of the upper urinary tract. Management is individualized according to symptom severity, prostate size, urinary flow, post-void residual urine, associated complications, comorbidities, and patient preference. Available treatment options range from watchful waiting, lifestyle modifications, and pharmacological therapy to minimally invasive procedures and conventional or laser-based surgical interventions. Recent technological advances have expanded therapeutic choices and improved safety, efficacy, recovery time, and preservation of urinary and sexual function. This review discusses the current evaluation and management of BPH, with particular emphasis on medical treatment, bipolar transurethral resection, laser procedures, and emerging minimally invasive interventions.

Keywords: Benign prostatic hyperplasia; Lower urinary tract symptoms; Medical therapy; Transurethral resection of the prostate; Bipolar TURP; Laser prostate surgery; Minimally invasive therapy.

Introduction:

Benign prostatic hyperplasia (BPH) is a prevalent condition among older men and can significantly affect quality of life. It is a histopathological diagnosis characterized by noncancerous enlargement of the prostate gland. The prevalence of BPH increases with age, being observed in approximately 8% of men aged 41–50 years, 40–50% of those aged 51–60 years, 70% of men aged 61–70 years, and more than 80% of men older than 80 years **(1)**.

The exact pathogenesis of BPH remains incompletely understood; however, several risk factors have been identified. These include race, family history of cancer, elevated serum levels of testosterone and estradiol, alcohol consumption, a history of prostatitis, and use of nonsteroidal anti-inflammatory drugs (NSAIDs). These factors may influence hormonal balance, inflammation, and cellular growth within the prostate, contributing to disease progression **(2)**.

The hallmark of BPH is the presence of lower urinary tract symptoms (LUTS), which result from bladder outlet obstruction or increased smooth muscle tone in the prostate and bladder neck. Common symptoms include increased urinary frequency, nocturia, urgency, urinary incontinence, weak or intermittent urinary stream, straining during urination, and terminal dribbling. These symptoms are experienced at a moderate to severe level by approximately 25% of men in their 50s, 33% in their 60s, and around 50% in their 80s **(3)**.

Evaluation of a patient with suspected BPH begins with a comprehensive medical history and physical examination, including digital rectal examination. The International Prostate Symptom Score (IPSS) is a standardized tool used to quantify the severity of LUTS and assess their impact on the patient's quality of life. The IPSS questionnaire consists of seven items addressing key urinary symptoms and one additional question evaluating the overall effect of these symptoms on daily living and wellbeing **(4)**.

Management of Benign Prostatic Hyperplasia

The management of benign prostatic hyperplasia (BPH) is guided by the American Urological Association (AUA) recommendations and depends on the severity of symptoms as well as the presence or absence of complications **(5)**.

For patients with mild symptoms (International Prostate Symptom Score, IPSS < 8), the preferred approach is watchful waiting. This conservative strategy involves regular monitoring and lifestyle modifications without immediate medical or surgical treatment. It is also appropriate for patients with moderate-to-severe symptoms who have not developed complications such as renal insufficiency, urinary retention, or recurrent urinary tract infections **(6)**.

Patients with moderate-to-severe symptoms (IPSS ≥ 8) are typically managed with medical therapy. Two main classes of medications are used for treatment:

α-blockers, which relax the smooth muscles of the prostate and bladder neck to enhance urine flow, and 5-α reductase inhibitors, which shrink the prostate gland by blocking the conversion of testosterone to dihydrotestosterone (DHT). These medications may be used alone or in combination depending on symptom severity and prostate size **(7)**.

Surgical intervention is indicated for patients with moderate-to-severe symptoms who have not responded to medical treatment, or for those who experience complications such as acute urinary retention, recurrent infection, or renal dysfunction. Surgery may also be chosen as a first-line option by patients seeking the most definitive and rapid symptom relief. Although many individuals undergo surgery after an unsuccessful trial of medication, a failed medical trial is not a prerequisite for surgical management when symptoms are particularly bothersome or significantly affect quality of life **(8)**.

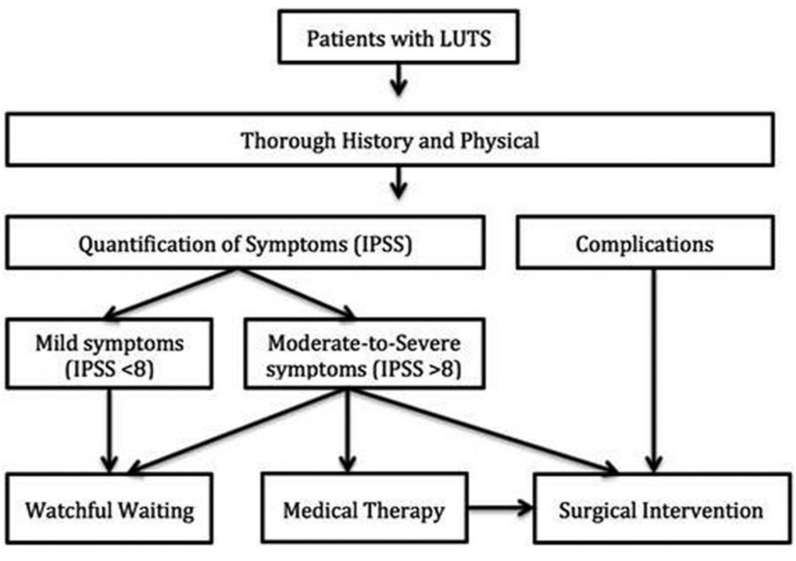

Figure 1: Medical and surgical management of benign prostatic hyperplasia (BPH) according to symptom severity and complications (9).

Table 1: Complications of BPH-associated bladder outlet obstruction (9).

Complications of BPH
Renal insufficiency
Acute urinary retention
Urinary tract infection
Bladder stones
Bladder decompensation
Urinary incontinence
Upper urinary tract deterioration and azotemia
Hematuria

Lifestyle Interventions

Low- to moderate-quality evidence suggests that self-management strategies can improve lower urinary tract symptoms (LUTS). These strategies include limiting evening fluid intake, reducing caffeine and alcohol consumption, and toilet/bladder training. Toilet training techniques include double voiding, repeated urination effort, urethral milking, and massaging the urethra from behind the scrotum toward the penis base. Bladder training involves incremental delayed voiding, pelvic floor exercises, or mindfulness practices. Low-quality evidence also suggests that sitting while urinating reduces postvoid urinary volume **(10)**.

Medical Therapy

First- and second-line medications are used to treat LUTS associated with BPH. Alpha-blockers and phosphodiesterase-5 inhibitors are considered first-line therapies. Combining these drugs increases adverse effects such as headache and muscle pain, with only slight additional benefit **(11)**.

Alpha-blockers provide rapid symptom improvement compared with placebo, and this benefit is consistent across different drugs. Nonselective alpha-blockers, such as terazosin and doxazosin, lower blood pressure more than selective alpha-1 blockers like tamsulosin and alfuzosin. Selective alpha-blockers are more likely to cause ejaculatory dysfunction, whereas nonselective drugs more commonly cause orthostatic hypotension. Taking selective alpha-blockers, every other day may reduce ejaculatory side effects while maintaining effectiveness. Alpha-blockers should be avoided prior to cataract surgery due to the risk of floppy iris syndrome. In cases of acute urinary retention, alpha-blockers are started at catheterization and continued for three days before attempting catheter removal **(12)**.

Phosphodiesterase-5 inhibitors, such as tadalafil, are similarly effective as alpha-blockers, even in men without erectile dysfunction. They are first-line options for men with coexisting BPH and erectile dysfunction **(13)**.

5-Alpha Reductase Inhibitors (5-ARIs), such as finasteride and dutasteride, improve LUTS, particularly in men with low urinary flow or large prostates. Guidelines recommend 5-ARIs if prostate volume ≥30 mL, enlarged prostate on examination, or PSA >1.5 ng/mL. Effects are delayed, taking up to one year, but benefits can last up to 10 years. Finasteride reduces the progression of BPH, risk of urinary retention, and need for surgery. Combining 5-ARIs with alpha-blockers is more effective than either alone after more than one year, but not within the first year. Adverse effects include erectile dysfunction, decreased libido, and abnormal ejaculation, with PSA values reduced by up to 50%, requiring adjustment for cancer screening. Long-term use may slightly delay cancer diagnosis and increase the risk of high-grade prostate cancers **(14)**.

Anticholinergic medications (e.g., solifenacin, oxybutynin, tolterodine) can be used alone or with alpha-blockers in patients with storage-predominant LUTS, though benefits are uncertain. Use is limited by the risk of acute urinary retention, dementia, and mental status changes, especially in older men **(15)**.

Beta-3 agonist mirabegron does not significantly improve LUTS compared with placebo. Desmopressin provides minimal improvement in nocturia relative to placebo **(16)**.

Table 2: Medication Treatment Options for Lower Urinary Tract Symptoms of BPH (17).

Medication class	Evidence summary	Pros	Cons
First line			
Alpha blockers	Lower IPSS by 2 to 4 points based on 21 RCTs with more than 10,000 patients[11]	Improvement is a class effect Rapid improvement of symptoms Low cost	Caution with use around cataract surgery because of floppy iris syndrome Adverse effects of orthostatic hypotension and ejaculatory dysfunction[8,18]
Phosphodiesterase-5 inhibitors	Demonstrate similar effectiveness to alpha blockers based on a Cochrane review of four trials with 933 patients[8]; effect is the same in patients without erectile dysfunction	Dual effects in patients with both BPH and erectile dysfunction	Combination with alpha blockers has only slight added benefit over either medication alone Mild adverse effect of headache is most common[11,19]
Second line			
5-Alpha reductase inhibitors	Lower IPSS score by 1 to 2 points based on 14 RCTs with nearly 15,000 patients[11] Decreased volume of prostate by 15% to 25% at six months based on three RCTs with nearly 4,000 men[5]	Decrease progression of BPH at four years Decrease the risk of urinary retention and surgical intervention[20] Combining with alpha blockers is more effective than either medication alone at one year[12]	Full symptom improvement can take up to a year Adverse effects of erectile dysfunction, decreased libido, and abnormal ejaculation[20,21] Decreases prostate-specific antigen value; risk of delay in diagnosis of prostate cancer[22]
Anticholinergics	Combination therapy with alpha blockers lowers IPSS score by 2 points compared with alpha blockers alone; evidence from 19 RCTs with 3,631 patients, but very low certainty because of high risk of bias and heterogeneity[23]	Combining with alpha blockers may improve quality of life but is uncertain in clinical significance[23]	Risks of acute urinary retention, dementia, and mental status changes, especially in older population[24]

Complementary Therapy

High-quality evidence shows that saw palmetto does not improve lower urinary tract symptoms (LUTS) or prostate volume compared with placebo, based on 32 long-term randomized controlled trials involving 5,666 men. Small, short-duration, low-quality studies suggest that Pygeum africanum may improve LUTS and urinary flow, although evidence is limited. Beta-sitosterol, a phytotherapeutic compound, appears to improve urinary symptoms and flow, but its long-term effectiveness and safety remain unknown. A small, low-quality study found that acupuncture did not improve LUTS **(18)**.

Surgical Therapy

Surgical intervention may be indicated in cases of failure of lifestyle or medical therapy, intolerable adverse effects, or signs of poor control such as renal insufficiency, urinary retention, recurrent urinary tract infections, or persistent gross hematuria. Only about 1% of men treated for LUTS from BPH undergo procedural or surgical interventions. Decisions regarding specific surgical or minimally invasive therapies should involve shared decision-making, taking into account procedural risks, including sexual side effects, procedural effectiveness, and retreatment risk **(6)**.

Transurethral resection of the prostate (TURP) is the primary surgical treatment for men with average-sized prostates (30–80 mL) who do not respond to medical therapy. TURP is the most effective treatment option, but risks include bleeding, incontinence, and adverse sexual effects **(19)**.

Minimally invasive surgical therapies often have fewer adverse effects than TURP but may lack high-quality evidence or have higher retreatment rates. Many are office-based procedures that do not require general anesthesia or cessation of anticoagulation **(20)**.

For small prostates (<30 mL), TURP or minimally invasive transurethral incision of the prostate may be considered. For large prostates (>80 mL), simple prostatectomy is recommended over TURP, with bipolar transurethral enucleation or holmium laser enucleation as less invasive alternatives **(21)**.

Bipolar Transurethral Resection of the Prostate (BiTURP):

Bipolar Technology

The development of bipolar loops allows the use of isotonic saline during surgery. In this design, the resectoscope or loop contains both the active and return electrodes in close proximity, meaning the current only travels a short distance. This reduces the voltage required, decreases tissue damage and charring, and theoretically results in sharper resections, less bleeding, and reduced postoperative irritative symptoms. Additionally, the reduced current spread minimizes damage to surrounding tissues, including the sphincter, urethra, and cavernosal nerves **(22)**.

Bipolar technology evolved from monopolar vaporization techniques, which achieved high currents and used broad electrodes to vaporize tissue. Unlike vaporization, resection allows tissue chips to be collected for histopathology and is generally faster. Modern bipolar TURP (BiTURP) combines resection and partial vaporization (~20% of tissue vaporized, the rest resected as chips) **(23)**.

BiTURP requires specialized surgical equipment, including electrocautery generators capable of bipolar current, which modulate voltage according to tissue impedance for smooth cutting. Typical settings are 120–280 W for cutting and 60–120 W for coagulation, using a 26Fr continuous flow resectoscope. Early BiTURP devices include the PK (PlasmaKinetic) system by Gyrus/ACMI and the TURiS system by Olympus, each paired with dedicated generators. Some manufacturers, like Karl Storz and Richard Wolf, offer combination loop/resectoscopes compatible with multiple generators **(24)**.

The placement of the return electrode differs among systems and is designed to optimize current flow and surgical safety. In the PK system, the return electrode is located on the loop itself and is separated from the cutting element by a few millimeters of insulation. In the Storz system, the return electrode is positioned opposite the active loop. For the Wolf and TURiS systems, the inner sheath of the resectoscope acts as the return electrode **(25)**.

Manufacturers now provide loops and electrodes of different shapes and thicknesses, allowing for resection, vaporization, and coagulation. This variety improves surgical flexibility, enabling surgeons to customize the approach based on patient anatomy, prostate size, and procedural goals **(26)**.

Figure 2: The Gyrus PK SuperSect loop (27)

Figure 3: Gyrus PK generator (27).

Surgical Techniqueset up

The basic difference in the surgical technique for BiTURP, compared with monopolar TURP, is the ability to operate for longer periods without concern for dilutional hyponatremia. All BiTURP devices utilize continuous irrigation, allowing uninterrupted surgery. The cutting electrode loop generates a “plasma corona” before starting the resection. During the procedure, accumulation of charred tissue on the loop may increase impedance. This tissue can often be dislodged by activating the loop in the bladder without contacting any tissue, eliminating the need to remove and manually clean the loop. Coagulation does not require a corona and can be performed similarly to monopolar TURP **(28)**.

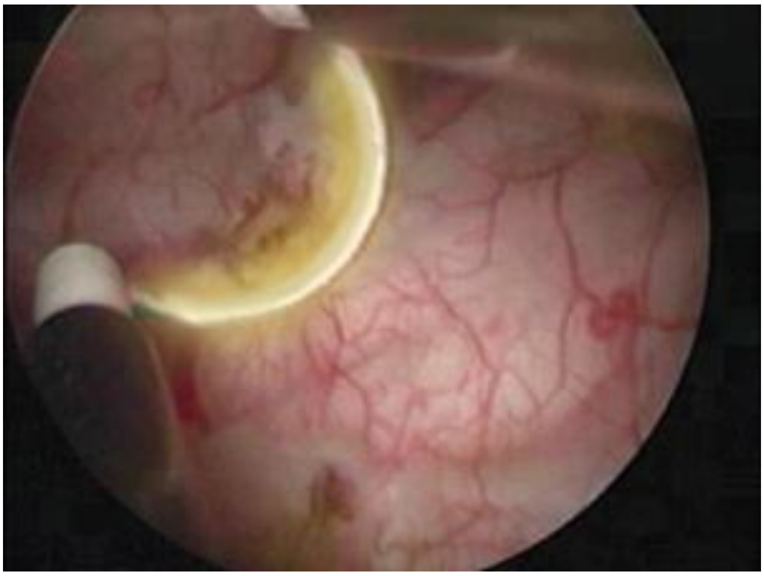

Figure 4: The plasma corona firing in the bladder (27).

Efficacy

The efficacy of BiTURP has been demonstrated in multiple studies since its introduction. In 2001, Botto et al. conducted a pilot study of 42 patients undergoing electrovaporization of the prostate using the Gyrus PK system. At 3 months, there was no significant postoperative bleeding, with only two strictures reported. Mean catheterization time was 1.4 days, and length of stay was 2.2 days. The IPSS decreased from 16 to 9, and peak flow rate increased from 7.9 to 19.7 mL/s **(29)**.

Subsequent studies continued to show comparable or superior outcomes with BiTURP versus monopolar TURP. Yang et al. reported similar improvements in IPSS and peak flow rates at 3 months, with BiTURP demonstrating equivalent efficacy and a lower risk of TUR syndrome. De Sio et al. found shorter operative and catheterization times with BiTURP and similar 12-month functional outcomes **(30)**.

In patients with large prostates (>60 g), BiTURP was associated with lower blood loss and smaller changes in serum sodium compared to monopolar TURP, suggesting improved safety in high-risk cases. Large-scale studies, including 401 patients using the Gyrus PK system, reported no intraoperative complications and sustained improvement in IPSS and flow rates up to 3 years **(31)**.

Newer devices, such as the Olympus TURis BiTURP system, confirmed these findings, showing lower blood loss and reduced risk of dilutional hyponatremia while maintaining comparable functional outcomes. Meta-analyses and systematic reviews, including studies by Mamoulakis et al. and Lee et al., support that BiTURP achieves equivalent or superior efficacy compared to monopolar TURP, with additional advantages of lower complication rates, reduced catheterization time, and better overall patient satisfaction **(30)**.

Conventional transurethral resection of the prostate (TURP) involves introducing a rigid resectoscope through the urethra to reach the prostate and resecting tissue with a metal loop that conducts electrical current. The first-generation TURP used monopolar current, but advances have led to the development of bipolar TURP (BiTURP). In BiTURP, both the active and return electrodes are contained within the loop, reducing the distance the current travels compared with monopolar systems **(32)**.

A key advantage of BiTURP is the ability to use isotonic saline as the irrigation fluid instead of glycine, minimizing the risk of dilutional hyponatremia and allowing longer operative times safely. Clinical studies have shown that BiTURP is associated with comparable or fewer complications than monopolar TURP, including similar rates of urethral stricture and bladder neck contracture, and in some studies, lower clot retention rates **(33)**.

Meta-analyses have demonstrated that BiTURP provides greater reduction in IPSS scores, improved maximum urinary flow rates (Qmax), better bladder emptying (lower post-void residual urine), higher patient satisfaction, and shorter catheterization times compared with monopolar TURP **(34)**.

Problems of Conventional TURP

Bleeding

Bleeding during monopolar TURP (M-TURP) requiring blood transfusion occurs in 0.4%–7.1% of cases. Although rare, life-threatening bleeding may necessitate open prostate packing or selective arterial prostatic embolization. In cases of very large prostates or anticipated technical difficulty, open, laparoscopic, or robot-assisted prostatectomy are alternatives, although most modern urologists prefer transurethral techniques **(35)**.

With experience and improved technique, complication rates have decreased. Historically, blood transfusion rates after TURP dropped from 44% in the 1970s to 4% in the 1990s. Alternatives to M-TURP include bipolar TURP (B-TURP) and laser-based procedures (Holmium:YAG enucleation, KTP laser vaporization). B-TURP, introduced 15 years ago, uses high-frequency energy to create a plasma vapor layer that disintegrates tissue locally, reducing thermal damage to surrounding tissue. Studies show no major differences between M-TURP and B-TURP in efficacy or postoperative outcomes, but B-TURP has a lower risk of TUR syndrome and reduced clot retention. Randomized trials demonstrate less blood loss and lower transfusion rates with B-TURP **(36)**.

Holmium laser enucleation of the prostate (HoLEP), introduced in 1998, allows treatment of large prostates with minimal bleeding by dissecting prostate lobes off the surgical capsule and removing them via morcellation **(37)**.

TUR Syndrome

TUR syndrome is caused by dilutional hyponatremia due to absorption of hypotonic irrigation fluid (commonly 1.5% glycine) during M-TURP. Symptoms include mental confusion, nausea, vomiting, hypertension, bradycardia, and visual disturbances, and untreated cases can result in cerebral edema and death. Prevention includes correcting pre-existing hyponatremia, limiting irrigation height to 60 cm, restricting procedure duration to 1 hour, and avoiding capsular perforation or bladder overdistension **(26)**.

The use of isotonic sodium chloride irrigation in B-TURP has virtually eliminated TUR syndrome. Studies report no TUR syndrome in B-TURP versus cases in M-TURP, allowing safer resection of larger prostates and training of residents **(38)**.

Completeness

TURP effectively relieves obstruction, but reoperation rates range from 5% to 15.5%. Long-term studies show reoperation rates of 2.9%–7.4% at 1–8 years. Techniques like transurethral enucleation and resection of the prostate (TUERP) and plasma vaporization-assisted enucleation have been developed to improve resection completeness. TUERP has been shown to improve postoperative IPSS, urinary flow (Qmax), and reduce reoperations compared to bipolar TURP. HoLEP provides highly effective, long-term results, with only 0.7% reoperation rate at 10 years due to residual adenoma, demonstrating its superiority in complete removal of prostatic tissue **(39)**.

Greenlight Photo-Vaporization (G-PVP)

Greenlight photo-vaporization of the prostate (G-PVP) uses a 532-nm laser delivered through a cystoscope to vaporize prostatic tissue. Unlike TURP, the laser does not make direct contact with the tissue; the ideal working distance is 1–2 mm from the tissue surface. This wavelength is preferentially absorbed by hemoglobin, making it effective for the vascular tissue of the prostate. G-PVP offers several advantages over conventional TURP, including technical simplicity, reduced bleeding risk, and the ability to treat larger prostates with less physiological stress. Postoperative management typically involves analgesics, limited physical activity for 1 week, and a catheter for bladder drainage, usually removed after 1 day **(40)**.

Clinical studies, including those by Te et al., have shown significant improvements in AUA symptom scores, quality-of-life scores, maximum urinary flow rate (Qmax), and post-void residual (PVR) volume up to 12 months postoperatively. Complications are generally minor, including mild-to-moderate dysuria, transient hematuria, postoperative urinary retention, and retrograde ejaculation. G-PVP is also considered safe for anticoagulated patients, as studies report no clinically significant intraoperative bleeding or need for postoperative blood transfusions. Systematic reviews and meta-analyses have confirmed that G-PVP results in shorter catheterization times, shorter hospital stays, and lower rates of bleeding and clot retention compared with TURP, while providing comparable intermediate-term functional outcomes **(41)**.

Table 3: Comparison of G-PVP outcomes as compared with TURP in the treatment of symptomatic BPH (9).

Perioperative parameter evaluated	**Outcome**
Mean catheterization time	Shorter (−1.91 d)
Mean length of hospital stay	Shorter (−2.13 d)
Mean operation time	Longer (+19.64 min)
Safe for anticoagulated patients?	Yes (not with TURP)
Relative risk of blood transfusion	0.16 as compared with TURP
Relative risk of clot retention	0.14 as compared with TURP

Greenlight Laser Enucleation

Greenlight laser enucleation is an alternative to standard photo-vaporization that allows for rapid enucleation of prostate tissue followed by morcellation, making it suitable for very large prostates that would otherwise require open simple prostatectomy. There is no size limitation, and patients benefit from a minimally invasive approach **(42)**.

The procedure uses a 532-nm laser, similar to Greenlight vaporization. The technique begins with creating a midline groove at the 6-o'clock position of the median lobe down to the trigone, using quick sweeping and proximal–distal motions rather than broad sweeps. A second groove is made at the 5-o'clock side, and the tissue between the grooves is vaporized starting from the apex. A similar groove is created at the 7-o'clock side of the median lobe. The procedure is then repeated for the lateral lobes with grooves at 11-o'clock and 1-o'clock positions. After enucleation of the lateral lobes, the anterior prostate and apical tissue are vaporized, and small tissue fragments are morcellated and removed at the end of the procedure **(43)**.

Holmium Laser Ablation (HoLAP)

Holmium laser ablation of the prostate (HoLAP) is another minimally invasive laser technique that vaporizes prostatic tissue. It is effective for prostates of any size and is particularly suitable for anticoagulated patients due to its excellent hemostatic properties. HoLAP is also preferred in previously irradiated patients because of its minimal tissue penetration and reduced risk of overtreatment **(44)**.

The holmium laser has a wavelength of 2,100 nm, which is highly absorbed by water, allowing precise vaporization of prostate cells with effective hemostasis. Energy is delivered via small, flexible fibers controlled by a foot pedal, making it a safe and controllable modality with a relatively short learning curve. Postoperatively, patients typically have a two-way Foley catheter in place for 1–2 days, or 3–5 days if the patient was self-catheterizing before surgery. Medications such as antimuscarinics are continued, and α-blockers or 5-α-reductase inhibitors are discontinued or completed as prescribed **(45)**.

Studies comparing HoLAP and Greenlight PVP have shown similar improvements in urinary flow rate, post-void residual (PVR), IPSS scores, and patient bother scores, with durable results up to 3 years postoperatively **(46)**.

Holmium Laser Enucleation of the Prostate (HoLEP)

Holmium laser enucleation of the prostate (HoLEP) uses a 2,120 nm holmium laser delivered through a 6-F ureteral catheter for protection and performed with a 27-F continuous flow resectoscope. The procedure begins with bladder neck incisions at the 5-o'clock and 7-o'clock positions, followed by retrograde dissection of the median lobe toward the bladder neck **(46)**.

The lateral lobes are enucleated by extending the initial bladder neck incisions laterally and circumferentially toward the apex at the 2-o'clock and 10-o'clock positions. A 12-o'clock bladder neck incision is then made down to the capsule, and the lateral lobes are released circumferentially. Enucleated tissue is removed via morcellation **(47)**.

HoLEP has the highest level of evidence among laser techniques for BPH, is cost-effective, and can reliably replace open prostatectomy. A Foley catheter is typically placed and removed the following morning. HoLEP has shown superior outcomes compared with TURP in terms of Qmax, urodynamics, IPSS reduction, and catheter/hospital stay, with perioperative and late complication rates—such as acute urinary retention, urinary tract infection, bladder neck stricture, and urethral stricture similar to TURP **(48)**.

Randomized trials consistently demonstrate that HoLEP provides faster recovery, shorter hospitalization, and greater functional improvement, making it the most extensively studied and effective laser modality for BPH surgery **(49)**.

Plasma Button Vaporization

Plasma Button vaporization uses plasma kinetic technology to vaporize prostatic tissue while achieving hemostasis. The system generates an ionized plasma corona using radiofrequency energy transmitted through an axipolar “button”-shaped electrode, which functions as both the active and return electrode. The energy operates at 320–450 kHz, 350–450 V, with a 200-W capacity **(50)**.

Compared with monopolar TURP, bipolar plasmakinetic vaporization (BPKVP) offers advantages including lower rates of clot retention, TUR syndrome, hematuria, and rehospitalization for bleeding. It also allows shorter operative times with a similar complication profile and results in greater reductions in IPSS and post-void residual (PVR) volumes **(51)**.

Transurethral Microwave Therapy (TUMT)

Transurethral microwave therapy (TUMT) is a minimally invasive option for patients who have failed medical therapy but wish to avoid surgery. A specialized urinary catheter positions a microwave antenna within the prostate, delivering heat (45–55°C) to ablate tissue, causing necrosis. The procedure is outpatient-based, typically lasting 30–60 minutes, and requires less anesthesia and shorter hospital stay compared with other modalities **(20).**

Postoperatively, catheterization is required, ranging from a few days to several weeks. Complications include hematuria, urinary retention, dysuria, urgency, UTIs, retrograde ejaculation, erectile dysfunction, and strictures. Compared with TURP, TUMT has lower rates of hospitalization, hematuria, clot retention, blood transfusion, TUR syndrome, and urethral strictures, but longer catheterization times, more dysuria, and urinary retention. Long-term follow-up shows sustained subjective improvements in IPSS, though Qmax declines after 24 months. The use of TUMT has declined due to limited long-term outcomes **(20)**.

Transurethral Needle Ablation (TUNA)

Transurethral needle ablation (TUNA) delivers low-level radiofrequency energy through adjustable needles placed in targeted areas of the prostate to induce localized necrosis. Ideal candidates have prostate volumes <60 g with lateral lobe involvement. The procedure can be performed in-office under topical anesthesia **(9)**.

Post procedure management includes a voiding trial or temporary catheterization. Common complications include acute urinary retention and irritative voiding symptoms. Studies show that about 14% of patients require additional intervention within 2 years. Meta-analyses demonstrate a 50% reduction in IPSS at 1 year, maintained for up to 5 years, with Qmax improvements of over 50%. Like TUMT, TUNA has fallen out of favor due to limited long-term results **(52)**.

Prostatic Tissue Approximation (Urolift)

The Urolift system is a minimally invasive prosthetic device designed to mechanically retract prostatic lobes and open the prostatic urethral space. It consists of a stainless-steel urethral tab and a nitinol capsular tab connected by a suture. The implant is placed transurethrally under endoscopic guidance, retracting the lobes toward the capsule **(53)**.

Urolift is typically performed outpatient under local anesthesia and is associated with lower morbidity than other surgical options. Common complications include hematuria, dysuria, and bladder spasms. An Australian multicenter study with 64 patients and 2-year follow-up showed IPSS reduction from 22.6 to 12.6 and peak urinary flow rate increase from 7.4 to 10.3 mL/s. Retreatment was required in 20% of patients, using either photoselective vaporization or TURP **(54)**.

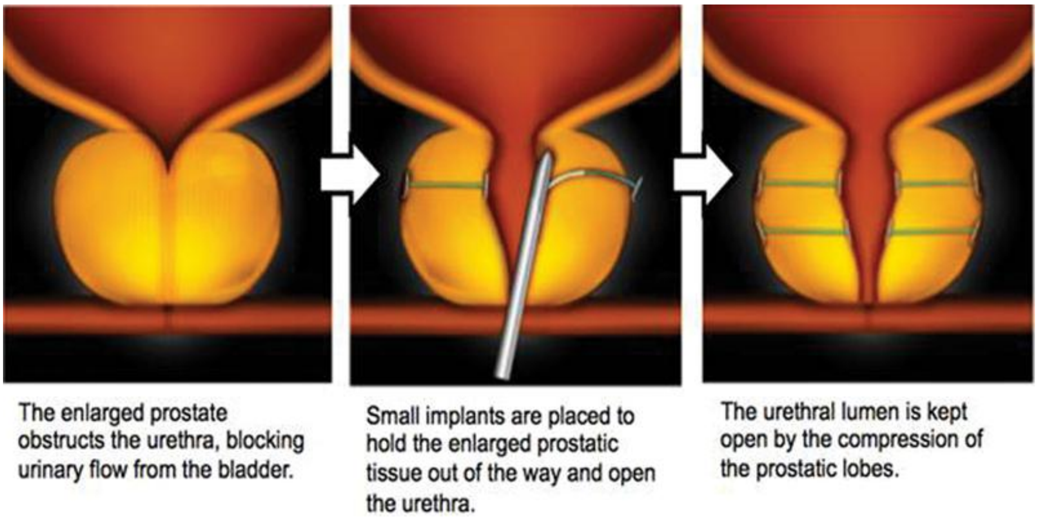

Figure 5: Urolift device illustration (9).

Prostatic Stents

Prostatic stents are devices designed to relieve obstruction in the prostatic urethra caused by enlarged prostate tissue. They are placed endoscopically to tent open adenomatous tissue and improve bladder outlet flow. Stents can be permanent or temporary. Permanent stents integrate with prostatic tissue through epithelialization, whereas temporary stents prevent tissue ingrowth and may be retrievable or biodegradable. Temporary stents are particularly useful for patients who are poor candidates for procedures under general anesthesia **(55)**.

In a 2007 systematic review of 990 patients receiving permanent UroLume Wallstents, 16% experienced stent failure at 1 year, mostly due to stent migration. Removal of failed stents can be challenging, often requiring general anesthesia. Clinical outcomes demonstrated IPSS reduction by 10 points to 12.4 and Qmax improvement by 4.2 mL/s to 13.1 mL/s **(56)**.

Prostatic Artery Embolization (PAE)

Prostatic artery embolization (PAE) is a minimally invasive procedure performed by an interventional radiologist under local anesthesia. It involves advancing a catheter through the femoral artery into the prostatic arteries, followed by injection of microspheres (100–500 μm) suspended in a saline/contrast solution to occlude blood flow and induce prostate shrinkage **(57)**.

Patients are advised to keep the punctured leg immobile for 4–6 hours post-procedure, and a Foley catheter is typically removed after 2–4 hours if the patient is not in acute urinary retention. PAE is indicated for patients >40 years with prostate volumes >30 cm³, refractory BPH symptoms, IPSS >18, QoL >3, or acute urinary retention. Exclusion criteria include malignancy, bladder anomalies, chronic renal failure, uncontrolled infection, coagulopathy, and severe arterial disease **(58)**.

Short-term outcomes (12 months) show a 50% decrease in IPSS, a 50% increase in Qmax, and improved QoL. Results at 24 months are similar, but long-term data are limited. MRI from two patients at 4 years suggested prostate regrowth, raising questions about the long-term efficacy of PAE. Common complications include nausea, vomiting, fever, dysuria, pelvic pain, and mild hematuria or hematochezia (“post-PAE syndrome”) **(59)**.

Ethanol Injection

Ethanol injection is a minimally invasive approach to reduce prostate size by destroying prostatic tissue. Under imaging guidance, 95–98% anhydrous ethanol is injected into the prostate, usually at the 3-o’clock and 9-o’clock positions, with an optional third injection for larger prostates. The volume ranges from 5 to 26 mL, often calculated based on TRUS-measured prostate volume **(60)**.

Ethanol induces tissue atrophy through inflammation, endothelial dehydration, and protein denaturation. The procedure can be performed in-office without anesthesia. The most common side effect is postoperative urinary retention requiring temporary catheterization. Other complications include dysuria, hematuria, and pelvic pain **(61)**.

A German review of 515 patients showed variable reductions in prostate volume and post-void residual, but all studies demonstrated significant improvements in IPSS, ranging from −40% to 74%, indicating symptomatic benefit despite variability in objective measures **(62)**.

Botox Injection

Botox (botulinum toxin) injection is an experimental approach for reducing prostatic outflow obstruction by decreasing smooth muscle tone and inducing prostatic atrophy. The procedure is performed under transrectal ultrasound guidance, with transperineal injections targeting the transition zone of the prostate. Botox works through chemical denervation, inhibiting smooth-muscle contraction and promoting tissue atrophy **(63)**.

This procedure can be performed on an outpatient basis and does not require general anesthesia. In a study by Sacco et al., no complications were reported during treatment or at 3-month follow-up. Patients experienced a 49% reduction in mean IPSS scores (from 19.7 to 10.0) and a 44% decrease in quality-of-life scores (from 4.17 to 2.3) **(64)**.

Currently, Botox injection remains investigational and is not considered standard urological care for BPH **(65)**.

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