Surgical treatment of benign prostatic hyperplasia (BPH)

Author: Kevin T McVary, MD, FACS
Section Editor: Michael P O'Leary, MD, MPH
Deputy Editor: Wenliang Chen, MD, PhD

All topics are updated as new evidence becomes available and our peer review process is complete.

Literature review current through: Aug 2022. | **This topic last updated:** Oct 22, 2021.

INTRODUCTION AND TERMINOLOGY

Benign prostatic hyperplasia (BPH) is defined as an increase in the total number of prostatic stromal cells and prostatic glandular epithelial cells within the transition zone of the prostate [1]. As a result of this hyperplasia, large, discrete prostatic nodules can develop. BPH and benign prostatic hypertrophy are often incorrectly used interchangeably. This is an error as benign prostatic hypertrophy is defined as an increase in the size of the individual prostatic cells resulting in a global enlargement of the prostate gland with no discrete nodularity. Through a combination of these two processes, benign prostatic enlargement (BPE) results. If BPE leads to obstruction of the bladder neck in the absence of prostate cancer, benign prostatic obstruction (BPO) results. The prevalence of BPH increases with age [2]. In the United States, nearly 70 percent of men between 60 and 69 years and 80 percent of men age ≥70 years have some degree of BPH [3,4]. (See "Epidemiology and pathophysiology of benign prostatic hyperplasia".)

Lower urinary tract symptoms (LUTS) have been defined by an international consensus conference as a constellation of symptoms related to storage and/or voiding disturbances in aging men [5]. LUTS can be subdivided into symptoms of urinary storage (eg, urgency, frequency, and nocturia), urinary voiding (eg, straining to void, urinary intermittency, dysuria, and hesitancy), and post-voiding symptoms (eg, sensation of incomplete bladder emptying and post-void urinary dribbling). The prevalence and severity of LUTS in men also increase with age; the prevalence is low in men <40 years but approaches 80 percent in men >80 years. (See "Lower urinary tract symptoms in males".)

Lower urinary tract symptoms associated with benign prostatic hyperplasia (LUTS/BPH) can be treated with behavioral, pharmacologic, and surgical interventions, with treatment decisions based on symptom severity, patient goals, and clinician preference [6]. The indications for and techniques of surgery for BPH will be reviewed here. The clinical manifestations and medical management of BPH are discussed elsewhere. (See "Clinical manifestations and diagnostic evaluation of benign prostatic hyperplasia" and "Medical treatment of benign prostatic hyperplasia".)

ANATOMY OF THE PROSTATE

The prostate is classically divided into three different zones of tissue: the peripheral zone, transition zone, and central/periurethral zone (figure 1). BPH has its origin within the transition zone [7].

The transition zone is demarcated distally by the verumontanum, an important landmark that endoscopically represents the interface between BPH and the continence-preserving proximal rhabdosphincter. Secretions from the prostate, vas deferens, and seminal vesicle empty into the prostatic urethra at the verumontanum (ie, section of the urethra that traverses the prostate) (figure 2). Each of these structures contributes to the composition of the semen.

During most transurethral procedures performed for BPH, the transition zone is resected or ablated. Because the resection is limited to the area between the bladder neck and the verumontanum, the ejaculatory ducts should be spared but can be injured, which can lead to some discomfort during orgasm. The absent ejaculation following these transurethral procedures is likely related to the resection of the internal sphincter located at the bladder neck as a part of the transurethral resection of the prostate (TURP) procedure. (See 'Sexual side effects' below.)

INDICATIONS FOR SURGICAL TREATMENT OF BPH

- Lower urinary tract symptoms – The most common indication for surgical intervention is moderate-to-severe voiding symptoms attributed to BPH that are refractory to medical therapy. This has shifted in the last few decades from voiding symptoms without formal subjective or objective quantification. (See "Lower urinary tract symptoms in males" and "Medical treatment of benign prostatic hyperplasia".)

  In general, BPH should be treated medically first. However, patients do not need to "fail" medical therapy in order for surgery to be a good option for them. Outside the list of "classic" mandatory indications requiring surgery detailed below, it is reasonable to forego a trial of medical therapy for BPH and proceed directly to surgical intervention provided the patient has been adequately educated on the risk therein [8]. (See 'Patient counseling' below.)

- Refractory urinary retention – BPH is a common cause of acute urinary retention (AUR) in older men. Catheterization is the initial treatment, but subsequent treatment varies. AUR triggered by medication (eg, alpha-agonists or anticholinergics), anesthesia, or acute bacterial prostatitis can be treated with catheter drainage followed by a voiding trial [9]. An alpha blocker is commonly added to increase the chance of patients passing the voiding trial [10]. Patients with AUR who fail two or more voiding trials should be evaluated for possible surgical treatment of BPH. (See "Acute urinary retention".)

  An elevated or increasing post-void residual urine volume (PVR) is a possible indication for surgical intervention. However, one should remember that there can be significant variability in PVR when assessed over time [11]. (See 'Evaluation and preoperative testing' below.)

- Recurrent urinary tract infection (UTI) – Recurrent UTI attributed to BPH is considered a sign of progressed disease and a reasonable indication for surgical intervention. It is not clear how many such infections must occur before declaring these as "recurrent." It seems reasonable that the clinician also carefully evaluate etiology of a recurrent UTI attributed to BPH as there are many confounding factors therein. Related comorbidities associated with recurrent UTI include bladder stones, bladder diverticuli, and high PVR urine volumes.

- Recurrent gross hematuria – Recurrent and robust gross hematuria is an indication for treatment of the prostate once other causes (eg, infection, carcinoma, trauma) have been excluded. This may be done either electively in patients with recurrent bleeding or urgently in a patient presenting for clot retention or continued hemorrhage despite more conservative management options [12]. (See "Etiology and evaluation of hematuria in adults".)

- Recurrent bladder stones – The findings of bladder calculi, bladder diverticula, and other signs of end-stage bladder decompensation are also possible indications for surgical intervention. While bladder calculi were a classical indication for surgical treatment of BPH in the past, the 2019 American Urological Association (AUA) guidelines recommended that any bladder calculi be removed and a trial of medical management be instituted before surgical intervention for BPH [6].

- Bilateral hydronephrosis with renal functional impairment – This presentation mandates relief of the bladder outlet obstruction in order to preserve the upper urinary tract and renal function. With catheterization and relief of obstruction, a postoperative diuresis may ensue. If the level of obstruction is confirmed at the bladder outlet, definitive surgical care should be delayed until after the patient's general medical condition has been optimized and any sequelae of the obstruction (impaired renal function, edema, etc) have been fully evaluated or have returned to a baseline status.

  If bilateral hydronephrosis (or elevated serum creatinine) is not relieved by catheter drainage, additional studies may be required. As an example, in patients with long-standing bladder outlet obstruction (BOO) leading to a hypertonic and thickened bladder, the ureters could be obstructed at the level of the bladder and ureteral stenting may help. Although routine screening for upper tract dilation is not required in patients with BPH, it may be helpful in these settings. (See 'Evaluation and preoperative testing' below.)

PREOPERATIVE PREPARATION

Evaluation and preoperative testing

Patient evaluation — A complete medical history should be taken to assess patient symptoms, prior procedures, sexual history, use of medications, and overall fitness and health.

The American Urological Association Symptom Index (AUA-SI [ie, International Prostate Symptom Score, IPSS]), which is a validated self-administered questionnaire, can provide clinicians with information regarding the symptom burden patients are experiencing.

A physical examination should be performed [13].

Urological testing — Additional studies that may be used to confirm the diagnosis or evaluate the severity of BPH include post-void residual urine volume (PVR), uroflowmetry, and pressure flow studies. The 2019 American Urological Association (AUA) BPH guidelines recommend that PVR be measured in all patients, and uroflowmetry and/or pressure flow studies be considered in select patients, prior to a surgical intervention for BPH [6].

- A PVR can be used to establish a baseline ability of the bladder to empty, detect severe urinary retention that may not be amenable to medical therapy, and/or indicate detrusor dysfunction. There is no universally accepted definition of a clinically significant residual urine volume, and likely following a trend over time is the best way to use this tool. (See "Lower urinary tract symptoms in males", section on 'Postvoid residual'.)

- Uroflowmetry measures the average urine flow rates, the shape of the voiding curve, duration of micturition, and maximum flow rates [1]. Flow rates less than 10 mL/sec have shown moderate specificity and positive predictive value for bladder outlet obstruction (BOO) [14]. (See "Lower urinary tract symptoms in males", section on 'Uroflowmetry'.)

- Pressure flow studies are indicated in patients in whom initial treatment of lower urinary tract symptoms (LUTS) has failed or in patients in whom multiple symptoms make the diagnosis of BOO unclear. If interventional therapy is planned without clear evidence of BOO (eg, peak urinary flow [Qmax] >10 mL/sec), the patient needs to be informed that the failure rates of the procedure may be higher. (See "Lower urinary tract symptoms in males", section on 'Pressure-flow studies and urodynamics'.)

Prostate imaging — The prostate volume assessment is critical when trying to match the best procedure to the prostate size, a relationship that impacts the outcome, durability, and risks of surgical procedures. Prostate anatomic variables such as an intravesical protrusion (eg, intravesical lobe, ball-valving middle lobe) have been recognized to predict poor outcomes from watchful waiting and most medical therapies as well as the presence of urodynamic obstruction [15].

Assessment of prostate size and morphology can be achieved by abdominal or transrectal ultrasonography, cystoscopy, or cross-sectional imaging techniques such as computed tomography (CT) or magnetic resonance imaging (MRI). Such imaging should provide cross-sectional and sagittal imaging of sufficient resolution to calculate prostate volume and assess the presence or absence of an intravesical lobe [16]. (See "Lower urinary tract symptoms in males", section on 'Transabdominal ultrasound'.)

Laboratory tests — Additionally, a urinalysis is a routine part of the evaluation for any man with LUTS. While a urinalysis cannot diagnose BPH, it can help rule out other causes of lower LUTS not associated with BPH through the detection of bacteria, blood, white blood cells, or protein in the urine. (See "Lower urinary tract symptoms in males", section on 'Initial patient evaluation'.)

The AUA BPH guidelines recommend prostate-specific antigen (PSA) screening for prostate cancer in appropriately aged men with a life expectancy of greater than 10 years. The guidelines for the detection of prostate cancer recognized that the greatest benefit for PSA screening is for men between 55 and 69 years of age [17]. PSA may also be used as a surrogate for prostate volume. (See "Screening for prostate cancer".)

Risk stratification and optimization — Preoperative evaluation and optimization also involves an assessment and stratification of surgical risk for the patient about to undergo a procedure. This assessment starts with a review of underlying frailty and cognition. This assessment helps inform potential postoperative needs. Risk stratification calculators are available for determining potential cardiac and pulmonary morbidity as well as overall surgical risk. Optimization of endocrine and gastrointestinal comorbidities can also reduce complications for patients. Modifiable preoperative behaviors and needs such as malnutrition and smoking cessation should also be considered prior to surgery.

Antibiotic prophylaxis — In general, prophylactic antibiotics should be administered within one hour before the procedure starts, with some exceptions (eg, vancomycin and fluoroquinolones) [18]. A single antibiotic dose or less than 24 hours of postoperative therapy is sufficient for routine prophylaxis. If a patient is already on scheduled antibiotics, an extra dose of an appropriate agent at the time of surgery is recommended to ensure adequate blood levels when surgery starts.

Antibiotic coverage for surgery should be carefully considered for each patient and with reference to the AUA Best Practice Statement [19]. The minimum coverage for transurethral procedures would include either cefazolin or sulfamethoxazole/trimethoprim (table 1). If the patient has an indwelling catheter (urethral or suprapubic), then extended coverage should be considered based on urine culture data [20,21].

Venous thromboembolism prophylaxis — The AUA's Best Practice Statement on venous thromboembolism (VTE) recommends against mechanical VTE prophylaxis in low-risk ambulatory patients undergoing transurethral surgery [22]. A 2019 review also recommended no specific prophylaxis beyond early ambulation for patients undergoing transurethral surgery [23].

Anticoagulation or antiplatelet therapy — Perioperative management of anticoagulation and antiplatelet medication in patients undergoing urologic procedures depends upon the specific medication(s) used, the indication for the medication(s), and the risk of bleeding associated with the planned procedure. Refer to the International Consultation on Urological Disease (ICUD)/AUA review on anticoagulation and antiplatelet therapy in urologic practice for further details [24].

Because BPH procedures are associated with varying risks of bleeding, the patient being on anticoagulation or antiplatelet medication is one of the factors to consider when selecting a procedure. (See 'Bleeding risk' below.)

Patient counseling — Patients should be counselled that interventions for LUTS/BPH could have sexual side effects. These treatments can cause a significant rate of ejaculatory dysfunction. Libido does not appear to be affected significantly by surgical therapy. While some studies have shown an improvement in erectile function after surgical treatment for BPH, others show a worsening of erectile function [25]. Most importantly, sexual side effects from surgical treatments are more likely to be permanent than those from medical treatments, which can often be reversed when the medication is stopped.

The patient's attitude toward potential sexual side effects may influence the choice of procedure. Several therapies have emerged that have little or no impact on sexual function (ie, water vapor thermal therapy and prostatic urethral lift). (See 'Sexual side effects' below.)

CHOICE OF PROCEDURE

Most surgical procedures for BPH are performed via the urethra using a specialized cystoscope. The exceptions are simple prostatectomy and prostatic artery embolization (experimental technique). The prostatic tissue can be removed (ie, resected), destroyed (ie, ablated), or compressed using a variety of energy sources, including electrocautery (diathermy), lasers, convective steam, capsular anchored compression, high-pressure saline, and microwave.

The choice of available procedures should be based on the size and shape of the prostate gland, the patient's bleeding risk, presentation (ie, concurrent stones, symptom severity), and his attitude toward potential sexual side effects. Equally important is the treating urologic surgeon's experience and preference.

All patients should be provided with the risk/benefit profile of all treatment options to allow them to make informed decisions regarding their treatment plans [6]. When certain treatment modalities are not available, clinicians should engage in a shared decision-making approach to reach a treatment choice, which may necessitate a referral to another clinician for the chosen treatment.

Additionally, all patients should be informed of possible treatment failure and the need for retreatment (medical, minimally invasive, or surgical), the rate of which generally correlates with the duration and completeness of follow-up [13].

Prostate size — The size and shape (ie, middle lobe present) of the prostate gland limits the applicability of some procedures. As examples, minimally invasive surgical treatments (MISTs), such as water vapor thermal therapy (WVTT) and prostatic urethral lift (PUL), can only be applied to prostates between 30 and 80 grams; larger prostates are better treated with simple prostatectomy or laser enucleation. The 2021 American Urological Association (AUA) guidelines provide a reasonable algorithm to select surgical therapy based on the volume and shape of the prostate (algorithm 1) [6].

Since digital rectal examination is unreliable in estimating prostate size and serum prostate-specific antigen (PSA) only provides a rough estimate of the prostate size, current guidelines recommend using preoperative prostate imaging to accurately assess the size and shape of the prostate and direct intervention [6,26]. (See 'Prostate imaging' above.)

Bleeding risk — For patients who are at a high risk of bleeding, such as those taking anticoagulation or antiplatelet medications, holmium laser enucleation of the prostate (HoLEP), thulium laser enucleation of the prostate (ThuLEP), and photoselective vaporization of the prostate (PVP) are preferred because they are associated with lower risk of bleeding/transfusion and can even be performed without interrupting the anticoagulation/antiplatelet therapy in some patients (algorithm 1) [6]. (See 'Anticoagulation or antiplatelet therapy' above.)

Sexual side effects — Surgical treatment of BPH has been known to cause ejaculatory dysfunction and worsen erectile function in some patients [27]. Thus, eligible patients who desire to preserve erectile and ejaculatory functions and do not mind the potential need for retreatment may be offered PUL or WVTT as data indicate greater preservation of sexual function with those two procedures (algorithm 1) [6]. Regardless of the chosen procedure, however, all patients should be counselled about the potential for sexual side effects. (See 'Patient counseling' above.)

MINIMALLY INVASIVE SURGICAL TREATMENTS

Many men with BPH discontinue medical therapy without seeking surgery due to the perceived invasiveness or potential side effects of the traditional procedures. Some of these men may be amenable to minimally invasive surgical treatments (MISTs).

Water vapor thermal therapy — Water vapor thermal therapy (WVTT) uses convective water vapor energy to ablate prostatic tissue (Rezūm system) [28]. Convective water vapor energy ablation creates no discernible thermal gradient, which is seen with conductive heat transfer such as in transurethral microwave therapy (TUMT). Consequently, no thermal effects occur outside the prostate or targeted treatment zone. The procedure can be performed in the office with minimal requirement for anesthetic or pain medications.

WVTT may be offered to patients with lower urinary tract symptoms associated with benign prostatic hyperplasia (LUTS/BPH) and a prostate volume between 30 and 80 grams, especially those who desire preservation of erectile and ejaculatory functions [6].

In a multicenter trial, 197 men were randomized in a 2:1 ratio to treatment with WVTT or sham control [29]. At three months, response to vapor treatment was significantly greater than to sham cystoscopy (74 versus 31 percent). The flow rate increased from 9.9 mL/sec to 16.1 mL/sec after WVTT compared with an increase from 10.4 mL/sec to 10.8 mL/sec in control patients. These outcomes were sustained throughout the five-year follow-up, no de novo erectile dysfunction was reported, and no significant changes in international index of erectile function-erectile function (IIEF-EF) or ejaculatory function scores were observed compared to the baseline [30].

Prostatic urethral lift — Prostatic urethral lift (PUL) is a nonablative approach to treating LUTS/BPH by a transprostatic tissue compression (Urolift System). The PUL device mechanically opens the prostatic urethra and relieves obstruction with a nitinol capsular anchor connected to a stainless steel urethral end piece by a monofilament suture that is tensioned in vivo. Men presenting with obstructing middle lobes of the prostate are not good candidates for this method.

PUL may be offered to patients with LUTS/BPH with a prostate volume of 30 to 80 grams and who are devoid of an obstructive middle lobe. In particular, it may be offered to eligible patients concerned about erectile and ejaculatory functions [6].

A sham-controlled trial (L.I.F.T. study) demonstrated that PUL provides relief of LUTS through five years with minimal side effects [31]. However, it also revealed deterioration of benefit, as one in three patients required retreatment of some sort (ie, return to medications, crossover to transurethral resection of the prostate [TURP] or photoselective vaporization of the prostate [PVP], additional intraoperative procedure for anchor encrustation).

Another trial comparing PUL with TURP (BPH-6) revealed that a lower proportion of men in the PUL group responded to treatment at 12 months (73 versus 91 percent) and 24 months as measured by the American Urological Association Symptom Index (AUA-SI; International Prostate Symptom Score [IPSS]) reduction goal of ≥30 percent [32,33]. Additionally, flow rate was significantly lower in men who underwent PUL at all follow-up intervals. However, there was no de novo ejaculatory dysfunction or erectile dysfunction seen with PUL procedures [34].

In a systematic review and meta-analysis, the annual surgical reintervention rate after PUL was about 6 percent (95% CI 3.0-8.9); reinterventions mainly consisted of TURP (51 percent), re-PUL (33 percent), and device explantation (20 percent). Higher rates were reported with longer follow-up [35].

PROSTATIC ABLATIVE THERAPIES

Monopolar transurethral resection of the prostate — Monopolar transurethral resection of the prostate (M-TURP) utilizes electrocautery energy passed across a thin filament loop to resect prostatic tissue from the level of the bladder neck to the verumontanum (figure 3 and figure 4).

The use of M-TURP has been in practice since the early 20th century. TURP remains the single best standard against which the effectiveness and safety of other interventions for lower urinary tract symptoms associated with benign prostatic hyperplasia (LUTS/BPH) are measured [6]. Although the original outcomes research for M-TURP predated many of the validated questionnaires for LUTS/BPH, TURP has long been believed to be an effective and durable BPH intervention [36].

Because the current supplied by a monopolar resectoscope is carried from the resecting loop to the prostatic tissue, a nonionic, hypo-osmolar irrigation solution must conduct the current back to the ground pad. Typical solutions include sterile water, sorbitol, and glycine. Given the extensive vascularity of the prostatic resection bed, these solutions can be absorbed into the systemic circulation. Excessive absorption of hypo-osmolar fluid can lead to a dilutional hyponatremia, a dangerous condition referred to as transurethral resection (TUR) syndrome. As such, it is recommended that postoperative serum electrolyte assessment be carried out in the postoperative care unit. (See "Hyponatremia following transurethral resection, hysteroscopy, or other procedures involving electrolyte-free irrigation".)

While TUR syndrome represents the most worrisome complication for M-TURP, it is uncommon. The more commonly cited complications of TURP include urinary tract infection (UTI), ejaculatory dysfunction, urethral stricture formation, and urinary incontinence, while up to 2.5 percent of individuals will require reoperation [37].

Complication rates following M-TURP generally rise with increasing resection time and increasing resected tissue volume. While no clear limits have been established, prolonged resection times should generally be avoided with monopolar approaches. Bipolar TURP was subsequently introduced to extend the safe duration and capacity of TURP. Alternatively, larger prostates can be treated with simple prostatectomy. (See 'Simple prostatectomy' below.)

Bipolar transurethral resection of the prostate — Bipolar transurethral resection of the prostate (B-TURP) contains the electrocautery current within the resecting loop, thus allowing iso-osmolar solutions (ie, normal saline) to be used, rather than hypo-osmolar solutions. Iso-osmolar solutions reduce the risk of TUR syndrome and improve hemostasis, both of which lead to decreased operative times [37] and the ability to resect larger glands [38].

Compared with M-TURP, B-TURP has similar efficacy [39] but significantly fewer adverse events, including bleeding, transfusion, duration of indwelling catheter, need for continuous bladder irrigation, and TUR syndrome [40].

Transurethral vaporization of the prostate — Transurethral electrovaporization of the prostate (TUVP) is an electrosurgical modification of the standard TURP platform. In TUVP, the current is applied to the prostatic tissue by an electrode to vaporize the prostatic tissue. TUVP can utilize a variety of energy delivery surfaces (electrodes), such as a spherical rolling electrode (rollerball), a grooved roller electrode (vaportrode), or a hemispherical mushroom electrode (button). TUVP typically uses saline irrigant, and the electrodes are powered by a bipolar energy source.

Compared with traditional TURP loop electrodes, the various designs of TUVP electrodes may improve tissue visualization, hemostasis, and tissue ablation speed/efficiency, all of which may translate into lower patient morbidity [41-43]. A meta-analysis of six randomized trials comparing plasma vaporization ("button procedure") with TURP found similar improvements in maximum urinary flow rates and symptom scores, but patients treated with plasma vaporization had fewer major complications and shorter duration of catheterization [44].

Transurethral incision of the prostate — The concept of incising the prostate at the level of the bladder neck to treat LUTS/BPH was first presented by Guthrie in 1834, suggesting that disruption of the bladder neck may allow the bladder to empty without restraint [45]. Usually, two deep incisions are made starting distal to each ureteral orifice and proceeding in an antegrade fashion through the bladder neck and the prostatic adenoma distally toward the verumontanum of the prostate. The incisions go down to, but not through, the capsule of the prostate. Bleeding is controlled with electrocautery. No prostatic tissue is removed.

Transurethral incision of the prostate (TUIP) has been used to treat LUTS/BPH in patients with small prostates (usually defined as ≤30 grams) for many decades [6]. One of the benefits of TUIP is preservation of antegrade ejaculation; a meta-analysis associated TUIP with a lower rate of retrograde ejaculation compared with TURP (18.2 versus 65.4 percent) [46]. However, avoidance of the bladder neck entirely is the best means to preserve ejaculatory function [47]. (See 'Sexual side effects' above.)

Photoselective vaporization of the prostate (PVP, laser TURP) — Photoselective vaporization of the prostate (PVP) utilizes laser energy at a wavelength of 532 nm to vaporize prostatic tissue. This wavelength of laser energy is selectively absorbed by hemoglobin, resulting in tissue ablation, leaving behind a thin layer of coagulation for hemostasis. Using an approach similar to

TURP, a channel is created within the prostatic urethral allowing the bladder to expel urine with minimal outlet resistance.

Many experts believe that PVP is best suited for older men with more complex medical comorbidities, those on long-term anticoagulation or antiplatelet therapy, and those with small- to medium-sized prostates. PVP is frequently performed as an ambulatory procedure, which provides significant cost savings over hospitalization.

Attributed to the thin layer of coagulation effect of the PVP, many believe this laser method holds a reduced risk of bleeding complications. Multiple studies have found PVP to be safe and effective for patients who continue their anticoagulant or antiplatelet therapy, with negligible transfusion rates, although longer periods of catheterization and irrigation, an increased complication rate, and delayed bleeding have been reported with PVP [48-51]. (See 'Bleeding risk' above.)

PVP may be more efficacious for smaller-volume prostates, and at least two studies have reported an increased risk of intraoperative conversion to TURP for prostate volumes >60 to 80 grams [52,53]. (See 'Prostate size' above.)

The 180W PVP was compared with TURP in a trial (GOLIATH) of 281 men with benign prostatic obstruction and prostate volume ≤80 grams [54]. At 6, 12, and 24 months, PVP was comparable to TURP in terms of International Prostate Symptom Score (IPSS), peak urinary flow (Qmax), reduction in prostate volume and post-void residual, adverse event incidence, transfusion requirement, and need for reoperation [55,56].

Laser enucleation of the prostate — Holmium laser enucleation of the prostate (HoLEP) and thulium laser enucleation of the prostate (ThuLEP) utilize energy generated by a holmium:yttrium-aluminum-garnet (YAG) laser or a thulium:YAG laser (figure 5). The energy, when absorbed by the irrigation fluid at the tip of the fiber, creates a vaporization bubble that destructs prostatic tissue with minimal deep tissue penetration. The transition zone of the prostate is enucleated along its surgical capsule with the resultant tissue morcellated using a separate device.

HoLEP and ThuLEP may be used to treat LUTS/BPH patients independent of the size of their prostates [6]. For men with prostate >100 grams, HoLEP resulted in shorter hospital stays, shorter catheter indwell times, and fewer perioperative bleeding complications while maintaining similar improvement in both American Urological Association Symptom Index (AUA-SI; IPSS) scores and urine flow rates at five years, compared with TURP [57]. For men with prostates <100 grams, HoLEP also resulted in similarly improved voiding symptoms, shorter catheter indwell time, and shorter hospitalization, compared with TURP [58]. HoLEP required a longer operative time and had a higher incidence of transient stress urinary incontinence than TURP.

HoLEP and ThuLEP are also options for patients who are at higher risk of bleeding, such as those on anticoagulation or antiplatelet therapy [59]. Both procedures were associated with a lower likelihood of blood transfusion compared with TURP [60,61]. In addition, continued anticoagulation and antiplatelet therapy has not been shown to adversely affect outcomes of HoLEP procedures, save for slightly longer duration of bladder irrigation and hospital stay [62].

Thulium laser can also be used to treat BPH by vaporizing the prostatic tissue [63]. In addition to HoLEP and ThuLEP, other laser modalities, such as diode and greenlight, have been utilized for enucleation [64].

Robotic waterjet treatment — Robot-assisted waterjet ablation of the prostate (RWT) is an emerging technique that uses an image-guided, robotically controlled waterjet to ablate prostatic tissue. The waterjet serves as a high-velocity hydrodissection tool that ablates prostatic parenchyma while sparing major blood vessels and the prostatic capsule. Transrectal ultrasound is used to map the prostate prior to the procedure. RWT is not a minimally invasive surgical treatment (MIST) procedure, because it requires general anesthesia. Despite significant setup time and effort, it can be performed efficiently.

RWT may be used to treat LUTS/BPH in patients with a prostate volume between 30 and 80 grams [6]. The presence of a large middle lobe and the requirement for general anesthesia are limitations to the technology in some trials [65].

At this time, it is not clear whether RWT offers any advantages over existing technologies. In a trial of 181 men with LUTS/BPH and prostate sizes between 30 and 80 grams, Aquablation and TURP achieved comparable treatment response through 12 months (>5 point improvement in AUA-SI/IPSS and increase in maximum flow rate) [66,67]. Adverse effect profiles such as the need for blood transfusion and reoperation were similar between RWT and TURP. It is not clear whether RWT offers advantages over TURP in terms of impact on sexual function [68].

Transurethral microwave therapy — Transurethral microwave therapy (TUMT) uses a specialized urethral catheter with an antenna that generates radially emitted electromagnetic (EM) waves in the frequency of 915 to 1296 MHz to induce changes with localized heat. The objective is to locally thermoablate prostate tissue while maintaining normal temperatures in the surrounding nontargeted tissue.

Microwave therapy has been gradually supplanted by other technologies with better analyzed trials. While a technically easier procedure than many of its counterparts, it carries a potentially prohibitive need for retreatment due to persistent LUTS/BPH. Despite a favorable overall complication profile compared with TURP, the risk of eventually requiring retreatment needs to be weighed carefully when considering TUMT for a patient. TUMT may be offered to patients with LUTS/BPH; however, patients should be informed that surgical retreatment rates are higher compared with TURP [6]. How the influx of newer MISTs that are office based will change the use of TUMT in the future is still yet to be seen.

Evidence for TUMT regarding efficacy, symptom improvement, adverse events, and urinary flow rates is inconsistent; multiple trials have compared TUMT to TURP or controls [69-76]. Response to treatment through 12 months was similar between TUMT and TURP. Those who underwent TUMT required more reoperations (risk ratio [RR] 7.07, 95% CI 1.94-25.82) but had a lower incidence of major adverse events (RR 0.20, 95% CI 0.09-0.43). The risk of erectile dysfunction was similar, but TUMT resulted in fewer cases of ejaculatory dysfunction (RR 0.36, 95% CI 0.24-0.53) [77].

Simple prostatectomy — Simple prostatectomy consists of enucleating the prostatic tissue with its capsule and can be performed via open, laparoscopic, or robotic approaches.

For the treatment of LUTS/BPH, simple prostatectomy is most commonly reserved for individuals with large (80 to 150 grams) or very large prostates (>150 grams) that would render transurethral techniques difficult. Although large prostates may be treated with transurethral techniques such as bipolar TURP or HoLEP, many urologists do not have access to or desire to use such techniques. Limitations of simple prostatectomy include the requirement for major surgery and postoperative hospital admission as well as the potential risk of significant perioperative blood loss.

Several trials compared simple prostatectomy with TURP [78-81]. Two trials reported greater improvement in maximum urine flow at 12 months after simple prostatectomy [79,80], while one trial found no difference between simple prostatectomy and TURP [78]. The need for blood transfusions was similar between the two groups. Two trials reported fewer reoperations after simple prostatectomy than after TURP [79,80]. One trial showed that the mean change in AUA-SI/IPSS through 36 months, blood transfusions, need for reoperation, and urinary incontinence were similar after laparoscopic simple prostatectomy versus TURP [81].

EXPERIMENTAL AND EMERGING TECHNOLOGIES

Prostatic arterial embolization — Prostatic arterial embolization (PAE) is an experimental minimally invasive surgical treatment (MIST) for BPH. Given the heterogeneity in the available literature and safety concerns regarding radiation exposure, postembolization syndrome, vascular access, technical feasibility, and adverse events [82], the American Urological Association (AUA) BPH clinical guidelines state that currently PAE should only be performed in the context of an experimental clinical trial [6,13].

PAE uses digital subtraction angiography to define the arterial anatomy and selectively embolize the appropriate prostatic arterial supply with beads, gels, or nonspherical polyvinyl alcohol. As a result, the prostate undergoes ischemic necrosis and subsequent volume reduction, which putatively relieves LUTS.

While all other technologies described above specifically target the critical areas of bladder outlet obstruction (BOO) caused by BPH, PAE impacts the entire prostate without exerting any focused and controlled action on the obstruction. This may explain the higher clinical failure rate compared with more traditional methods (eg, transurethral resection of the prostate [TURP]) [83-86] and the commonly observed complications such as acute urinary retention in almost 26 percent of cases [87].

Prostatic arteries may be very difficult to identify because of a lack of pathognomonic findings. Nontargeted embolization may lead to ischemic complications of the prostate, bladder, or seminal vesicles. Other short-term complications, including urethral burning sensation, nausea, and vomiting, which have been called the "post-PAE syndrome," are common [88]. Furthermore, radiation and contrast toxicity may lead to additional adverse events.

UTILIZATION

Since the advent of medical therapy for BPH, there has been a steady decline in the utilization of surgical therapies. Between 1999 and 2005, there was a 5 percent per year decrease in the number of transurethral resections of the prostate (TURP) [89]. There was a further 19.8 percent decrease from 2005 to 2008 [90]. As a result, patients who now undergo surgery for BPH are generally older [91] and have more medical comorbidities [92]. In addition, "failure of medical therapy" was the indication for surgery in essentially 0 percent of patients in 1988 but 87 percent in 2008 [93]. A report from the Urologic Diseases of America Project (UDA) also noted that medication usage increased and surgery decreased over the years 2003 to 2013 [4].

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Benign prostatic hyperplasia".)

SUMMARY AND RECOMMENDATIONS

- **Terminologies** – Benign prostatic hyperplasia (BPH) is increasingly common as men age. Men with BPH who are asymptomatic or have only mild symptoms do not require treatment. Those with more severe lower urinary tract symptoms (LUTS) may benefit from medical therapy. Surgical treatment is indicated when symptoms are refractory to medical therapy, the disease is advanced, or in those who do not want medical treatment. (See 'Introduction and terminology' above.)

- **Indications for surgery** – Men with BPH who develop upper urinary tract compromise (eg, hydronephrosis, renal insufficiency), refractory urinary retention, recurrent urinary tract infection, bladder decompensation, recurrent bladder calculi, or persistent gross hematuria require surgical treatment. (See 'Indications for surgical treatment of BPH' above.)

- **Preoperative testing** – Prior to any surgical treatment for BPH, men should undergo a complete history and physical examination, a post-void residual urine volume (PVR) measurement, and possibly uroflowmetry or pressure flow studies. Prostate imaging may also help choose the optimal technique for patients. Required laboratory tests include serum prostate-specific antigen and urinalysis and culture. (See 'Preoperative preparation' above.)

- **Choosing a procedure** – The choice of available procedures should be based on the size and shape of the prostate gland, the patient's bleeding risk, presentation (ie, concurrent stones, symptom severity), and his attitude toward potential sexual side effects. The 2021 American Urological Association (AUA) BPH guidelines provide a reasonable algorithm with which to select surgical therapy (algorithm 1). (See 'Choice of procedure' above.)

- **Treatment options** – Most procedures used in the treatment of BPH are performed transurethrally, including transurethral resection of the prostate (TURP), transurethral vaporization of the prostate (TUVP), transurethral laser enucleation (holmium laser enucleation of the prostate [HoLEP], thulium laser enucleation of the prostate [ThuLEP]), photoselective vaporization of the prostate (PVP), transurethral incision of the prostate (TUIP), transurethral microwave therapy (TUMT), robotic waterjet treatment (RWT), water vapor thermal therapy (WVTT), and prostatic urethral lift (PUL). Simple prostatectomy and prostatic arterial embolization (experimental procedure) are BPH procedures that are not performed transurethrally. (See 'Minimally invasive surgical treatments' above and 'Prostatic ablative therapies' above and 'Prostatic arterial embolization' above.)

ACKNOWLEDGMENTS

The UpToDate editorial staff acknowledges Glenn R Cunningham, MD, and Dov Kadmon, MD, who contributed to an earlier version of this topic review.

REFERENCES

1. Mahon JT, McVary KT. New alternative treatments for lower urinary tract symptoms secondary to benign prostatic hyperplasia. In: Minimally Invasive Urology: An Essential Clinical Guide to Endourology, Laparoscopy, LESS and Robotics, 2nd ed, Best SL, Nakada SY (Eds), Springer, Cham, Switzerland 2020. p.283.
2. Berry SJ, Coffey DS, Walsh PC, Ewing LL. The development of human benign prostatic hyperplasia with age. J Urol 1984; 132:474.
3. Wei JT, Calhoun E, Jacobsen SJ. Urologic diseases in America project: benign prostatic hyperplasia. J Urol 2005; 173:1256.
4. Welliver C, Feinstein L, Ward JB, et al. Trends in Lower Urinary Tract Symptoms Associated with Benign Prostatic Hyperplasia, 2004 to 2013: the Urologic Diseases in America Project. J Urol 2020; 203:171.
5. American Urological Association (AUA). Guideline. Benign Prostatic Hyperplasia: Surgical Management of Benign Prostatic Hyperplasia/Lower Urinary Tract Symptoms (2018, amended 2019). Available at: https://www.auanet.org/guidelines/benign-prostatic-hyperplasia-(bph)-guideline (Accessed on May 06, 2020).
6. Lerner LB, McVary KT, Barry MJ, et al. Management of Lower Urinary Tract Symptoms Attributed to Benign Prostatic Hyperplasia: AUA GUIDELINE PART II-Surgical Evaluation and Treatment. J Urol 2021; 206:818.
7. McNeal JE, Redwine EA, Freiha FS, Stamey TA. Zonal distribution of prostatic adenocarcinoma. Correlation with histologic pattern and direction of spread. Am J Surg Pathol 1988; 12:897.
8. McVary KT, Roehrborn CG, Avins AL, et al. Update on AUA guideline on the management of benign prostatic hyperplasia. J Urol 2011; 185:1793.

9. Jacobsen SJ, Jacobson DJ, Girman CJ, et al. Natural history of prostatism: risk factors for acute urinary retention. J Urol 1997; 158:481.
10. McNeill SA, Hargreave TB, Roehrborn CG, Alfaur study group. Alfuzosin 10 mg once daily in the management of acute urinary retention: results of a double-blind placebo-controlled study. Urology 2005; 65:83.
11. Bruskewitz RC, Iversen P, Madsen PO. Value of postvoid residual urine determination in evaluation of prostatism. Urology 1982; 20:602.
12. Borth CS, Nickel JC. Management of spontaneous prostate related bleeding. AUA Update Series. Vol. 25, Lesson 1. 2006.
13. Parsons JK, Dahm P, Köhler TS, et al. Surgical Management of Lower Urinary Tract Symptoms Attributed to Benign Prostatic Hyperplasia: AUA Guideline Amendment 2020. J Urol 2020; 204:799.
14. Reynard JM, Yang Q, Donovan JL, et al. The ICS-'BPH' Study: uroflowmetry, lower urinary tract symptoms and bladder outlet obstruction. Br J Urol 1998; 82:619.
15. Keqin Z, Zhishun X, Jing Z, et al. Clinical significance of intravesical prostatic protrusion in patients with benign prostatic enlargement. Urology 2007; 70:1096.
16. Lu SH, Chen CS. Natural history and epidemiology of benign prostatic hyperplasia. Formosan Journal of Surgery 2014; 47:207.
17. Carter HB, Albertsen PC, Barry MJ, et al. Early detection of prostate cancer: AUA Guideline. J Urol 2013; 190:419.
18. American Urological Association. White Paper: Optimizing Outcomes in Urologic Surgery: Intraoperative Considerations. 2018. Available at: https://www.auanet.org/guidelines/optimizing-outcomes-in-urologic-surgery-intraoperative-considerations (Accessed on December 26, 2019).
19. Lightner DJ, Wymer K, Sanchez J, Kavoussi L. Best Practice Statement on Urologic Procedures and Antimicrobial Prophylaxis. J Urol 2020; 203:351.
20. Warren JW, Tenney JH, Hoopes JM, et al. A prospective microbiologic study of bacteriuria in patients with chronic indwelling urethral catheters. J Infect Dis 1982; 146:719.
21. Bjork DT, Pelletier LL, Tight RR. Urinary tract infections with antibiotic resistant organisms in catheterized nursing home patients. Infect Control 1984; 5:173.
22. Forrest JB, Clemens JQ, Finamore P, et al. AUA Best Practice Statement for the prevention of deep vein thrombosis in patients undergoing urologic surgery. J Urol 2009; 181:1170.
23. Michalski W, Poniatowska G, Jonska-Gmyrek J, et al. Venous thromboprophylaxis in urological cancer surgery. Med Oncol 2019; 37:11.

24. Culkin DJ, Exaire EJ, Green D, et al. Anticoagulation and antiplatelet therapy in urological practice: ICUD/AUA review paper. J Urol 2014; 192:1026.
25. McConnell JD, Roehrborn CG, Bautista OM, et al. The long-term effect of doxazosin, finasteride, and combination therapy on the clinical progression of benign prostatic hyperplasia. N Engl J Med 2003; 349:2387.
26. Stone BV, Shoag J, Halpern JA, et al. Prostate size, nocturia and the digital rectal examination: a cohort study of 30 500 men. BJU Int 2017; 119:298.
27. Fwu CW, Eggers PW, Kirkali Z, et al. Change in sexual function in men with lower urinary tract symptoms/benign prostatic hyperplasia associated with long-term treatment with doxazosin, finasteride and combined therapy. J Urol 2014; 191:1828.
28. Mynderse LA, Hanson D, Robb RA, et al. Rezūm System Water Vapor Treatment for Lower Urinary Tract Symptoms/Benign Prostatic Hyperplasia: Validation of Convective Thermal Energy Transfer and Characterization With Magnetic Resonance Imaging and 3-Dimensional Renderings. Urology 2015; 86:122.
29. McVary KT, Gange SN, Gittelman MC, et al. Minimally Invasive Prostate Convective Water Vapor Energy Ablation: A Multicenter, Randomized, Controlled Study for the Treatment of Lower Urinary Tract Symptoms Secondary to Benign Prostatic Hyperplasia. J Urol 2016; 195:1529.
30. McVary KT, Gittelman MC, Goldberg KA, et al. Final 5-Year Outcomes of the Multicenter Randomized Sham-Controlled Trial of a Water Vapor Thermal Therapy for Treatment of Moderate to Severe Lower Urinary Tract Symptoms Secondary to Benign Prostatic Hyperplasia. J Urol 2021; 206:715.
31. Roehrborn CG, Barkin J, Gange SN, et al. Five year results of the prospective randomized controlled prostatic urethral L.I.F.T. study. Can J Urol 2017; 24:8802.
32. Gratzke C, Barber N, Speakman MJ, et al. Prostatic urethral lift vs transurethral resection of the prostate: 2-year results of the BPH6 prospective, multicentre, randomized study. BJU Int 2017; 119:767.
33. Sønksen J, Barber NJ, Speakman MJ, et al. Prospective, randomized, multinational study of prostatic urethral lift versus transurethral resection of the prostate: 12-month results from the BPH6 study. Eur Urol 2015; 68:643.
34. McVary KT, Gange SN, Shore ND, et al. Treatment of LUTS secondary to BPH while preserving sexual function: randomized controlled study of prostatic urethral lift. J Sex Med 2014; 11:279.

35. Miller LE, Chughtai B, Dornbier RA, McVary KT. Surgical Reintervention Rate after Prostatic Urethral Lift: Systematic Review and Meta-Analysis Involving over 2,000 Patients. J Urol 2020; 204:1019.
36. Wasson JH, Reda DJ, Bruskewitz RC, et al. A comparison of transurethral surgery with watchful waiting for moderate symptoms of benign prostatic hyperplasia. The Veterans Affairs Cooperative Study Group on Transurethral Resection of the Prostate. N Engl J Med 1995; 332:75.
37. Issa MM. Technological advances in transurethral resection of the prostate: bipolar versus monopolar TURP. J Endourol 2008; 22:1587.
38. Makar AB, McMartin KE, Palese M, Tephly TR. Formate assay in body fluids: application in methanol poisoning. Biochem Med 1975; 13:117.
39. Omar MI, Lam TB, Alexander CE, et al. Systematic review and meta-analysis of the clinical effectiveness of bipolar compared with monopolar transurethral resection of the prostate (TURP). BJU Int 2014; 113:24.
40. Cornu JN, Ahyai S, Bachmann A, et al. A Systematic Review and Meta-analysis of Functional Outcomes and Complications Following Transurethral Procedures for Lower Urinary Tract Symptoms Resulting from Benign Prostatic Obstruction: An Update. Eur Urol 2015; 67:1066.
41. Geavlete B, Multescu R, Dragutescu M, et al. Transurethral resection (TUR) in saline plasma vaporization of the prostate vs standard TUR of the prostate: 'the better choice' in benign prostatic hyperplasia? BJU Int 2010; 106:1695.
42. Nuhoğlu B, Balci MB, Aydin M, et al. The role of bipolar transurethral vaporization in the management of benign prostatic hyperplasia. Urol Int 2011; 87:400.
43. Geavlete B, Georgescu D, Multescu R, et al. Bipolar plasma vaporization vs monopolar and bipolar TURP-A prospective, randomized, long-term comparison. Urology 2011; 78:930.
44. Wroclawski ML, Carneiro A, Amarante RD, et al. 'Button type' bipolar plasma vaporisation of the prostate compared with standard transurethral resection: a systematic review and meta-analysis of short-term outcome studies. BJU Int 2016; 117:662.
45. Lourenco T, Shaw M, Fraser C, et al. The clinical effectiveness of transurethral incision of the prostate: a systematic review of randomised controlled trials. World J Urol 2010; 28:23.
46. Reich O, Gratzke C, Stief CG. Techniques and long-term results of surgical procedures for BPH. Eur Urol 2006; 49:970.
47. Orandi A. Transurethral incision of prostate compared with transurethral resection of prostate in 132 matching cases. J Urol 1987; 138:810.

48. Lee DJ, Rieken M, Halpern J, et al. Laser Vaporization of the Prostate With the 180-W XPS-Greenlight Laser in Patients With Ongoing Platelet Aggregation Inhibition and Oral Anticoagulation. Urology 2016; 91:167.
49. Woo HH, Hossack TA. Photoselective vaporization of the prostate with the 120-W lithium triborate laser in men taking coumadin. Urology 2011; 78:142.
50. Ruszat R, Wyler S, Forster T, et al. Safety and effectiveness of photoselective vaporization of the prostate (PVP) in patients on ongoing oral anticoagulation. Eur Urol 2007; 51:1031.
51. Brassetti A, DE Nunzio C, Delongchamps NB, et al. Green light vaporization of the prostate: is it an adult technique? Minerva Urol Nefrol 2017; 69:109.
52. Elhilali MM, Elkoushy MA. Greenlight laser vaporization versus transurethral resection of the prostate for the treatment of benign prostatic obstruction: evidence from randomized controlled studies. Transl Androl Urol 2016; 5:388.
53. Hueber PA, Ben-Zvi T, Liberman D, et al. Mid term outcomes of initial 250 case experience with GreenLight 120W-HPS photoselective vaporization prostatectomy for benign prostatic hyperplasia: comparison of prostate volumes < 60 cc, 60 cc-100 cc and > 100 cc. Can J Urol 2012; 19:6450.
54. Bachmann A, Tubaro A, Barber N, et al. 180-W XPS GreenLight laser vaporisation versus transurethral resection of the prostate for the treatment of benign prostatic obstruction: 6-month safety and efficacy results of a European Multicentre Randomised Trial--the GOLIATH study. Eur Urol 2014; 65:931.
55. Thomas JA, Tubaro A, Barber N, et al. A Multicenter Randomized Noninferiority Trial Comparing GreenLight-XPS Laser Vaporization of the Prostate and Transurethral Resection of the Prostate for the Treatment of Benign Prostatic Obstruction: Two-yr Outcomes of the GOLIATH Study. Eur Urol 2016; 69:94.
56. Bachmann A, Tubaro A, Barber N, et al. A European multicenter randomized noninferiority trial comparing 180 W GreenLight XPS laser vaporization and transurethral resection of the prostate for the treatment of benign prostatic obstruction: 12-month results of the GOLIATH study. J Urol 2015; 193:570.
57. Kuntz RM, Lehrich K, Ahyai SA. Holmium laser enucleation of the prostate versus open prostatectomy for prostates greater than 100 grams: 5-year follow-up results of a randomised clinical trial. Eur Urol 2008; 53:160.
58. Kuntz RM, Ahyai S, Lehrich K, Fayad A. Transurethral holmium laser enucleation of the prostate versus transurethral electrocautery resection of the prostate: a randomized prospective trial in 200 patients. J Urol 2004; 172:1012.

59. Foster HE, Barry MJ, Dahm P, et al. Surgical Management of Lower Urinary Tract Symptoms Attributed to Benign Prostatic Hyperplasia: AUA Guideline. J Urol 2018; 200:612.
60. Zhong J, Feng Z, Peng Y, Liang H. A Systematic Review and Meta-analysis of Efficacy and Safety Following Holmium Laser Enucleation of Prostate and Transurethral Resection of Prostate for Benign Prostatic Hyperplasia. Urology 2019; 131:14.
61. Zhu Y, Zhuo J, Xu D, et al. Thulium laser versus standard transurethral resection of the prostate for benign prostatic obstruction: a systematic review and meta-analysis. World J Urol 2015; 33:509.
62. El Tayeb MM, Jacob JM, Bhojani N, et al. Holmium Laser Enucleation of the Prostate in Patients Requiring Anticoagulation. J Endourol 2016; 30:805.
63. Hashim H, Worthington J, Abrams P, et al. Thulium laser transurethral vaporesection of the prostate versus transurethral resection of the prostate for men with lower urinary tract symptoms or urinary retention (UNBLOCS): a randomised controlled trial. Lancet 2020; 396:50.
64. Zhang J, Wang X, Zhang Y, et al. 1470 nm Diode Laser Enucleation vs Plasmakinetic Resection of the Prostate for Benign Prostatic Hyperplasia: A Randomized Study. J Endourol 2019; 33:211.
65. Gilling P, Anderson P, Tan A. Aquablation of the Prostate for Symptomatic Benign Prostatic Hyperplasia: 1-Year Results. J Urol 2017; 197:1565.
66. Gilling PJ, Barber N, Bidair M, et al. Randomized Controlled Trial of Aquablation versus Transurethral Resection of the Prostate in Benign Prostatic Hyperplasia: One-year Outcomes. Urology 2019; 125:169.
67. Gilling P, Barber N, Bidair M, et al. WATER: A Double-Blind, Randomized, Controlled Trial of Aquablation® vs Transurethral Resection of the Prostate in Benign Prostatic Hyperplasia. J Urol 2018; 199:1252.
68. Hwang EC, Jung JH, Borofsky M, et al. Aquablation of the prostate for the treatment of lower urinary tract symptoms in men with benign prostatic hyperplasia. Cochrane Database Syst Rev 2019; 2:CD013143.
69. De La Rosette JJ, Floratos DL, Severens JL, et al. Transurethral resection vs microwave thermotherapy of the prostate: a cost-consequences analysis. BJU Int 2003; 92:713.
70. Floratos DL, Kiemeney LA, Rossi C, et al. Long-term followup of randomized transurethral microwave thermotherapy versus transurethral prostatic resection study. J Urol 2001; 165:1533.

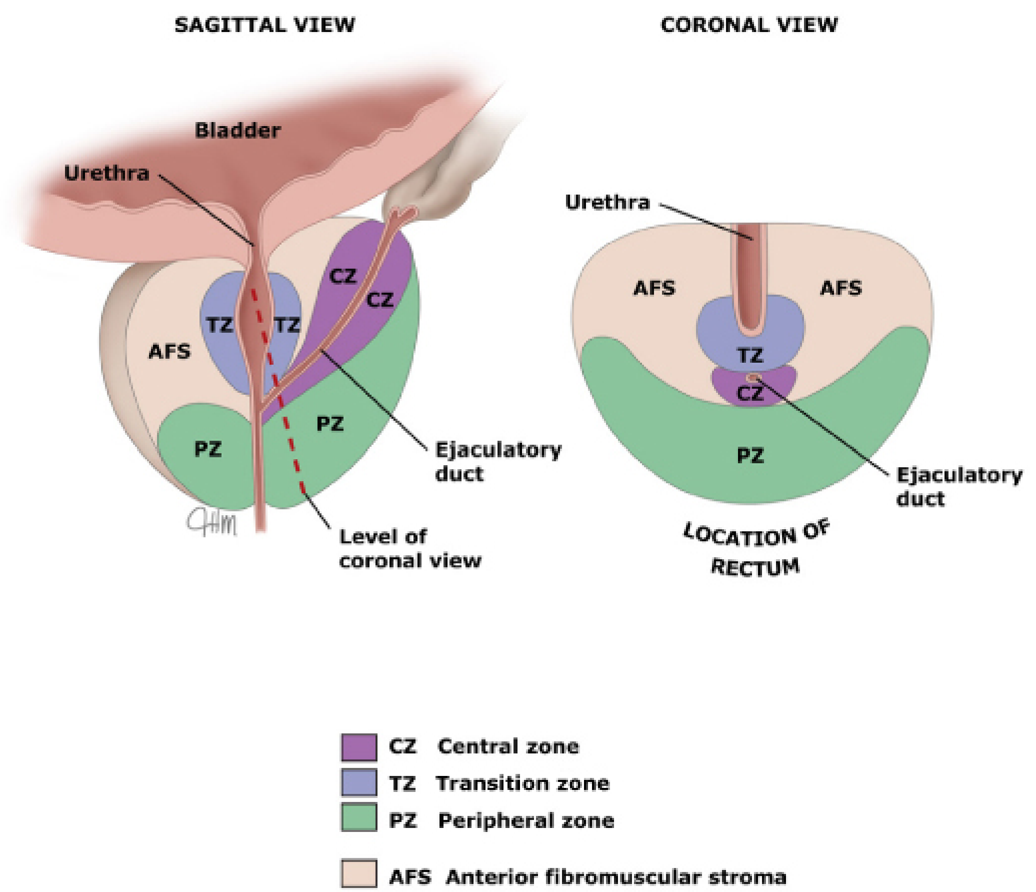
71. Nørby B, Nielsen HV, Frimodt-Møller PC. Transurethral interstitial laser coagulation of the prostate and transurethral microwave thermotherapy vs transurethral resection or incision of the prostate: results of a randomized, controlled study in patients with symptomatic benign prostatic hyperplasia. BJU Int 2002; 90:853.
72. Schelin S, Geertsen U, Walter S, et al. Feedback microwave thermotherapy versus TURP/prostate enucleation surgery in patients with benign prostatic hyperplasia and persistent urinary retention: a prospective, randomized, controlled, multicenter study. Urology 2006; 68:795.
73. Wagrell L, Schelin S, Nordling J, et al. Feedback microwave thermotherapy versus TURP for clinical BPH--a randomized controlled multicenter study. Urology 2002; 60:292.
74. Wagrell L, Schelin S, Nordling J, et al. Three-year follow-up of feedback microwave thermotherapy versus TURP for clinical BPH: a prospective randomized multicenter study. Urology 2004; 64:698.
75. Mattiasson A, Wagrell L, Schelin S, et al. Five-year follow-up of feedback microwave thermotherapy versus TURP for clinical BPH: a prospective randomized multicenter study. Urology 2007; 69:91.
76. Zhang B, Wu G, Chen C, et al. Combination of channel-TURP and ILC versus standard TURP or ILC for elderly with benign prostatic hyperplasia: a randomized prospective trial. Urol Int 2011; 87:392.
77. Franco JV, Garegnani L, Escobar Liquitay CM, et al. Transurethral microwave thermotherapy for the treatment of lower urinary tract symptoms in men with benign prostatic hyperplasia. Cochrane Database Syst Rev 2021; 6:CD004135.
78. Geavlete B, Bulai C, Ene C, et al. Bipolar vaporization, resection, and enucleation versus open prostatectomy: optimal treatment alternatives in large prostate cases? J Endourol 2015; 29:323.
79. Ou R, You M, Tang P, et al. A randomized trial of transvesical prostatectomy versus transurethral resection of the prostate for prostate greater than 80 mL. Urology 2010; 76:958.
80. Simforoosh N, Abdi H, Kashi AH, et al. Open prostatectomy versus transurethral resection of the prostate, where are we standing in the new era? A randomized controlled trial. Urol J 2010; 7:262.
81. Xie JB, Tan YA, Wang FL, et al. Extraperitoneal laparoscopic adenomectomy (Madigan) versus bipolar transurethral resection of the prostate for benign prostatic hyperplasia greater than 80 ml: complications and functional outcomes after 3-year follow-up. J Endourol 2014; 28:353.

82. Jung JH, McCutcheon KA, Borofsky M, et al. Prostatic arterial embolization for the treatment of lower urinary tract symptoms in men with benign prostatic hyperplasia. Cochrane Database Syst Rev 2020; 12:CD012867.
83. Gao YA, Huang Y, Zhang R, et al. Benign prostatic hyperplasia: prostatic arterial embolization versus transurethral resection of the prostate--a prospective, randomized, and controlled clinical trial. Radiology 2014; 270:920.
84. Carnevale FC, Iscaife A, Yoshinaga EM, et al. Transurethral Resection of the Prostate (TURP) Versus Original and PErFecTED Prostate Artery Embolization (PAE) Due to Benign Prostatic Hyperplasia (BPH): Preliminary Results of a Single Center, Prospective, Urodynamic-Controlled Analysis. Cardiovasc Intervent Radiol 2016; 39:44.
85. Russo GI, Kurbatov D, Sansalone S, et al. Prostatic Arterial Embolization vs Open Prostatectomy: A 1-Year Matched-pair Analysis of Functional Outcomes and Morbidities. Urology 2015; 86:343.
86. Abt D, Müllhaupt G, Hechelhammer L, et al. Prostatic Artery Embolisation Versus Transurethral Resection of the Prostate for Benign Prostatic Hyperplasia: 2-yr Outcomes of a Randomised, Open-label, Single-centre Trial. Eur Urol 2021; 80:34.
87. Pisco JM, Bilhim T, Costa NV, et al. Randomised Clinical Trial of Prostatic Artery Embolisation Versus a Sham Procedure for Benign Prostatic Hyperplasia. Eur Urol 2020; 77:354.
88. Carnevale FC, da Motta-Leal-Filho JM, Antunes AA, et al. Quality of life and clinical symptom improvement support prostatic artery embolization for patients with acute urinary retention caused by benign prostatic hyperplasia. J Vasc Interv Radiol 2013; 24:535.
89. Wasson JH, Bubolz TA, Lu-Yao GL, et al. Transurethral resection of the prostate among medicare beneficiaries: 1984 to 1997. For the Patient Outcomes Research Team for Prostatic Diseases. J Urol 2000; 164:1212.
90. Malaeb BS, Yu X, McBean AM, Elliott SP. National trends in surgical therapy for benign prostatic hyperplasia in the United States (2000-2008). Urology 2012; 79:1111.
91. Vela-Navarrete R, Gonzalez-Enguita C, Garcia-Cardoso JV, et al. The impact of medical therapy on surgery for benign prostatic hyperplasia: a study comparing changes in a decade (1992-2002). BJU Int 2005; 96:1045.
92. Choi SY, Kim TH, Myung SC, et al. Impact of changing trends in medical therapy on surgery for benign prostatic hyperplasia over two decades. Korean J Urol 2012; 53:23.
93. Izard J, Nickel JC. Impact of medical therapy on transurethral resection of the prostate: two decades of change. BJU Int 2011; 108:89.

Topic 8093 Version 41.0

GRAPHICS

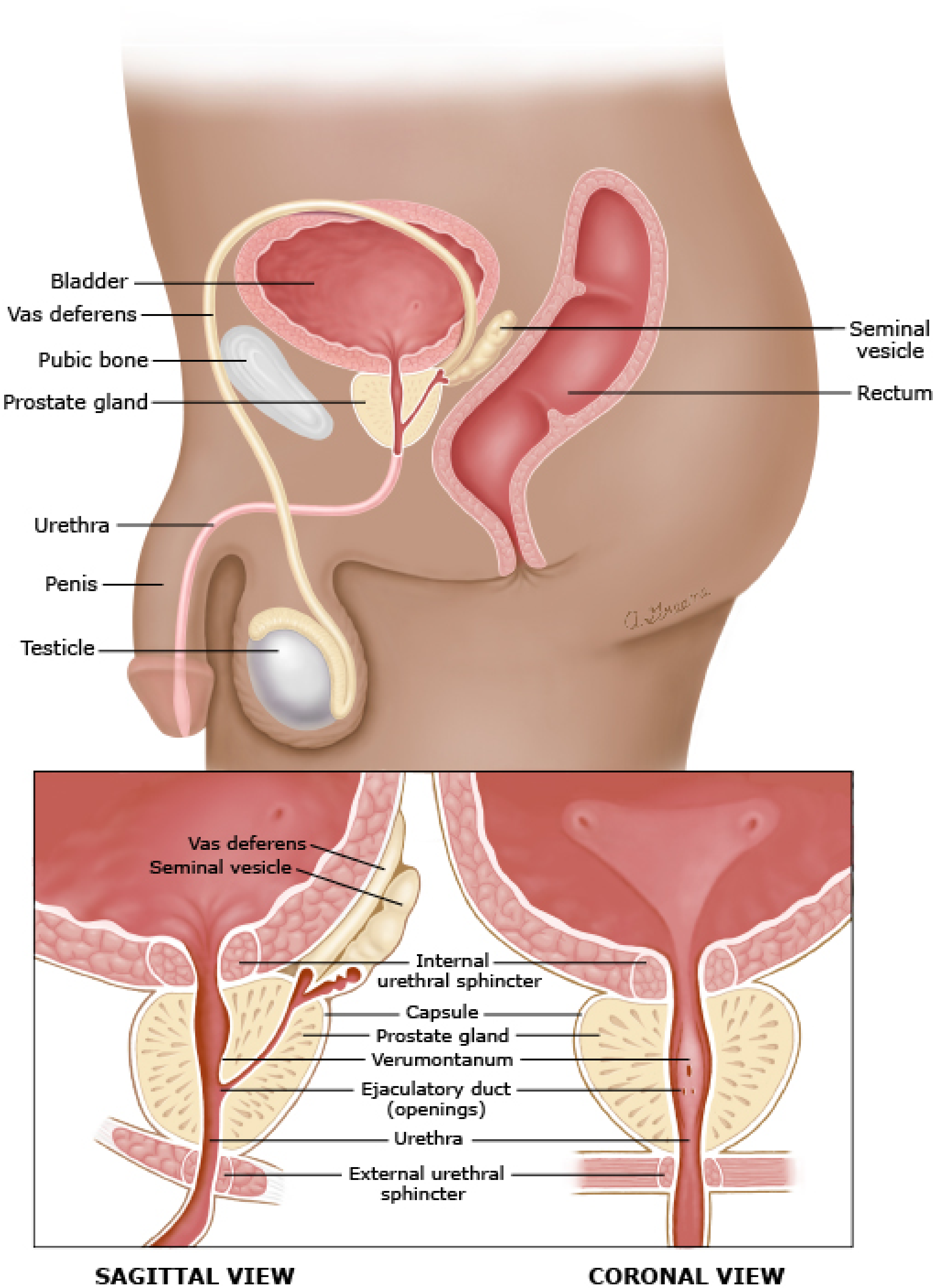
Zones of the prostate gland



The bulk of the prostate gland is contained within the peripheral zone. The transition zone is the site of benign prostatic hypertrophy. The majority of prostate cancers originate in the peripheral zone, whereas only 5 and 10% originate from the central and transition zones, respectively.

Graphic 57801 Version 3.0

Prostate anatomy



The prostate gland is a walnut-shaped structure located at the base of the urinary bladder. The prostate gland is composed of both glandular and muscular tissue. Secretions from the prostate, vas deferens, and seminal vesicle empty into the prostatic urethra.

Graphic 54803 Version 9.0

Recommended antimicrobial prophylaxis for urologic procedures

Procedure	Likely organisms	Prophylaxis indicated	Antimicrobial(s) of choice	Alternative antimicrobial(s) required
Lower tract instrumentation				
Cystourethroscopy with minor manipulation, break in mucosal barriers, biopsy, fulguration, etc; clean-contaminated	GNR, rarely enterococci[¶]	Uncertain[Δ]; consider host-related risk factors. Increasing invasiveness increases risk of SSI.	TMP-SMX, amoxicillin/clavulanate	First/second-generation cephalosporin + aminoglycoside (aztreonam[◊]) ± ampicillin
Transurethral cases (eg, TURP, TURBT, laser enucleative and ablative procedures, etc); clean-contaminated[§]	GNR, rarely enterococci	All cases	Cefazolin, TMP-SMX	Amoxicillin/clavulan aminoglycoside (aztreonam[◊]) ± ampicillin
Prostate brachytherapy or cryotherapy; clean-contaminated	*Staphylococcus aureus*, skin; GNR	All cases	Cefazolin	Clindamycin[¥]
Transrectal prostate biopsy; contaminated	GNR, anaerobes[‡]; consider MDR coverage, if risks of systemic antibiotics within six months, international travel, health care worker	All cases	Fluoroquinolone, first/second/third-generation cephalosporin (ceftriaxone commonly used) + aminoglycoside	Aztreonam May need to conside ID consultation
Upper tract instrumentation				
Percutaneous renal surgery (eg,	GNR, rarely enterococci,	All cases	First/second-generation	Ampicillin/sulbactan

PCNL); clean-contaminated	and skin[†], *S. aureus*		cephalosporin, aminoglycoside (aztreonam[◊]) + metronidazole, or clindamycin	
Ureteroscopy, all indications; clean-contaminated	GNR, rarely enterococci	All cases; of undetermined benefit for uncomplicated, diagnostic-only procedures	TMP-SMX, first/second-generation cephalosporin	Aminoglycoside (aztreonam[◊]) ± ampicillin, first/seco generation cephalosporin, amoxicillin/clavulan
Open, laparoscopic, or robotic surgery				
Without entering urinary tract (eg, adrenalectomy, lymphadenectomy, retroperitoneal or pelvic); clean	*S. aureus*, skin	Consider in all cases; may not be required	Cefazolin	Clindamycin
Penile surgery (eg, circumcision, penile biopsy, etc); clean-contaminated	*S. aureus*	Likely not required		
Urethroplasty; reconstruction of the anterior urethra; stricture repair, including urethrectomy; clean; contaminated; controlled entry into the urinary tract	GNR, rarely enterococci, *S. aureus*	Likely required	Cefazolin	Cefoxitin, cefotetan, ampicillin/sulbactan
Involving controlled entry into urinary tract (eg, renal surgery; nephrectomy, partial or otherwise; ureterectomy; pyeloplasty; radical	GNR (*Escherichia coli*), rarely enterococci	All cases	Cefazolin, TMP-SMX	Ampicillin/sulbactan aminoglycoside (aztreonam[◊]) + metronidazole, or clindamycin

prostatectomy); partial cystectomy, etc; clean-contaminated				
Involving small bowel (ie, urinary diversions, cystectomy with small bowel conduit, other GU procedures); ureteropelvic junction repair, partial cystectomy, etc; clean-contaminated	Skin, *S. aureus*, GNR, rarely enterococci	All cases	Cefazolin	Clindamycin and aminoglycoside, cefuroxime (second-generation cephalosporin), aminopenicillin combined with a bet lactamase inhibitor metronidazole
Involving large bowel**; colon conduits; clean-contaminated	GNR, anaerobes	All cases	Cefazolin + metronidazole, cefoxitin, cefotetan, or ceftriaxone + metronidazole, ertapenem NB: These IV agents are used along with mechanical bowel preparation and oral antimicrobial (neomycin sulfate + erythromycin base or neomycin sulfate + metronidazole)	Ampicillin/sulbactan ticarcillin/clavulanat piperacillin/tazobact
Implanted prosthetic devices: AUS, IPP, sacral neuromodulators; clean	GNR, *S. aureus*, with increasing reports of anaerobic and fungal organisms	All cases	Aminoglycoside (aztreonam◊) + first/second-generation cephalosporin or vancomycin¶¶	Aminopenicillin beta lactamase inhibitor, including ampicillin/sulbactam ticarcillin, or tazobactam
Inguinal and scrotal cases (eg, radical orchiectomy, vasectomy, reversals,	GNR, *S. aureus*	Of increased risk; all cases	Cefazolin	Ampicillin/sulbactan

varicocelectomy, hydrocelectomy, etc); clean				
Vaginal surgery, female incontinence (eg, urethral sling procedures, fistulae repair, urethral diverticulectomy, etc); clean-contaminated	*S. aureus*, streptococci, enterococci, vaginal anaerobes; skin	All	Second-generation cephalosporin (cefoxitin, cefotetan) provides better anaerobic coverage than first-generation cephalosporins; however, cefazolin is equivalent coverage for the vaginal anaerobes in sling procedures	Ampicillin/sulbactan aminoglycoside (aztreonam◇) + metronidazole, or clindamycin
Other				
Shock-wave lithotripsy; clean	GNR, rarely enterococci; GU pathogens	Only if risk factors	If risks, consider TMP-SMX, first-generation cephalosporin (cefazolin), second-generation cephalosporin (cefuroxime), aminopenicillin combined with a beta-lactamase inhibitor + metronidazole	First/second-generation cephalosporin, amoxicillin/clavulana ampicillin + aminoglycoside (aztreonam◇), clindamycin

GNR: gram-negative rod; SSI: surgical site infection; TMP-SMX: sulfamethoxazole and trimethoprim; TURP: transurethral resection of the prostate; TURBT: transurethral resection of bladder tumor; MDR: multidrug resistant; ID: infectious diseases; PCNL: percutaneous nephrolithotomy; GU: genitourinary; IV: intravenous; AUS: artificial genitourinary sphincter; IPP: implantable penile prosthesis; GPC: gram-positive cocci; AP: antimicrobial prophylaxis.

* Or full course of culture-directed antimicrobials for documented infection (which is treatment, not prophylaxis).

¶ GU GNR: Common urinary tract organisms are *E. coli*, *Proteus* spp, *Klebsiella* spp, and GPC *Enterococcus*.

Δ If urine culture shows no growth prior to the procedure, antimicrobial prophylaxis is not necessary.

◇ Aztreonam can be substituted for aminoglycosides in patients with renal insufficiency.

§ Includes transurethral resection of bladder tumor and prostate and any biopsy, resection, fulguration, foreign body removal, urethral dilation or urethrotomy, or ureteral instrumentation including catheterization or stent placement/removal.

¥ Clindamycin, or aminoglycoside + metronidazole or clindamycin, are general alternatives to penicillins and cephalosporins in patients with penicillin allergy, even when not specifically listed.

‡ Intestine: Common intestinal organisms include aerobes and anaerobes: *E. coli*, *Klebsiella* spp, *Enterobacter*, *Serratia* spp, *Proteus* spp, *Enterococcus*, and *Anaerobes*.

† Skin: Common skin organisms are *S. aureus*, coagulase-negative *Staphylococcus* spp, Group A *Streptococcus* spp.

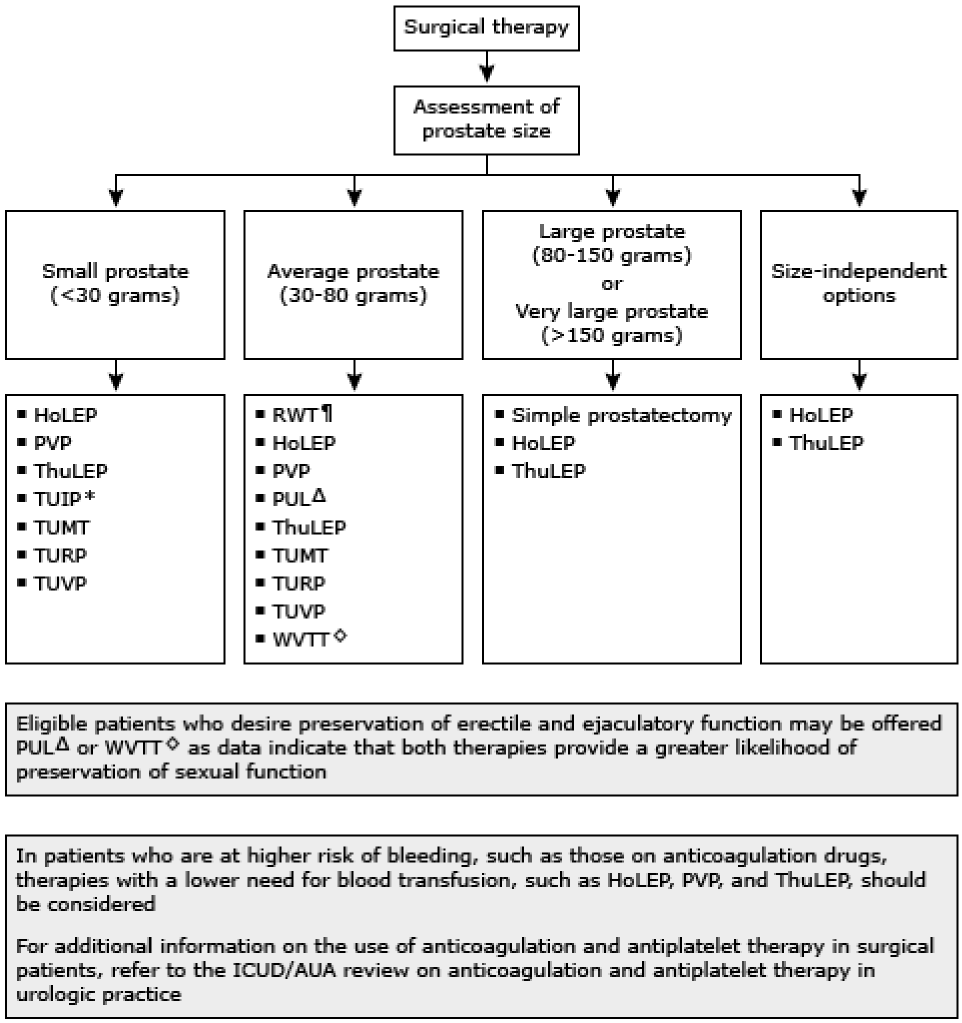
** For surgery involving the colorectum, bowel preparation with oral neomycin plus either erythromycin base or metronidazole is added to systemic agents.

¶¶ Routine administration of vancomycin for AP is not recommended. The antimicrobial spectrum of vancomycin is less effective against methicillin-sensitive strains of *S. aureus*.

From: Lightner DJ, Wymer K, Sanchez J, Kavoussi L. Best practice statement on urologic procedures and antimicrobial prophylaxis. J Urol 2020; 203:351. DOI: 10.1097/JU.0000000000000509.

Graphic 129971 Version 1.0

Benign prostatic hyperplasia surgery selection algorithm



HoLEP: holmium laser enucleation of the prostate; PVP: photoselective vaporization of the prostate; ThuLEP: thulium laser enucleation of the prostate; TUIP: transurethral incision of the prostate; TUMT: transurethral microwave therapy; TURP: transurethral resection of the prostate; TUVP: transurethral electrovaporization of the prostate; RWT: robotic waterjet treatment; PUL: prostatic urethral lift; WVTT: water vapor thermal therapy; ICUD: International Consultation on Urological Disease; AUA: American Urological Association.

* TUIP requires a prostate <30 grams.

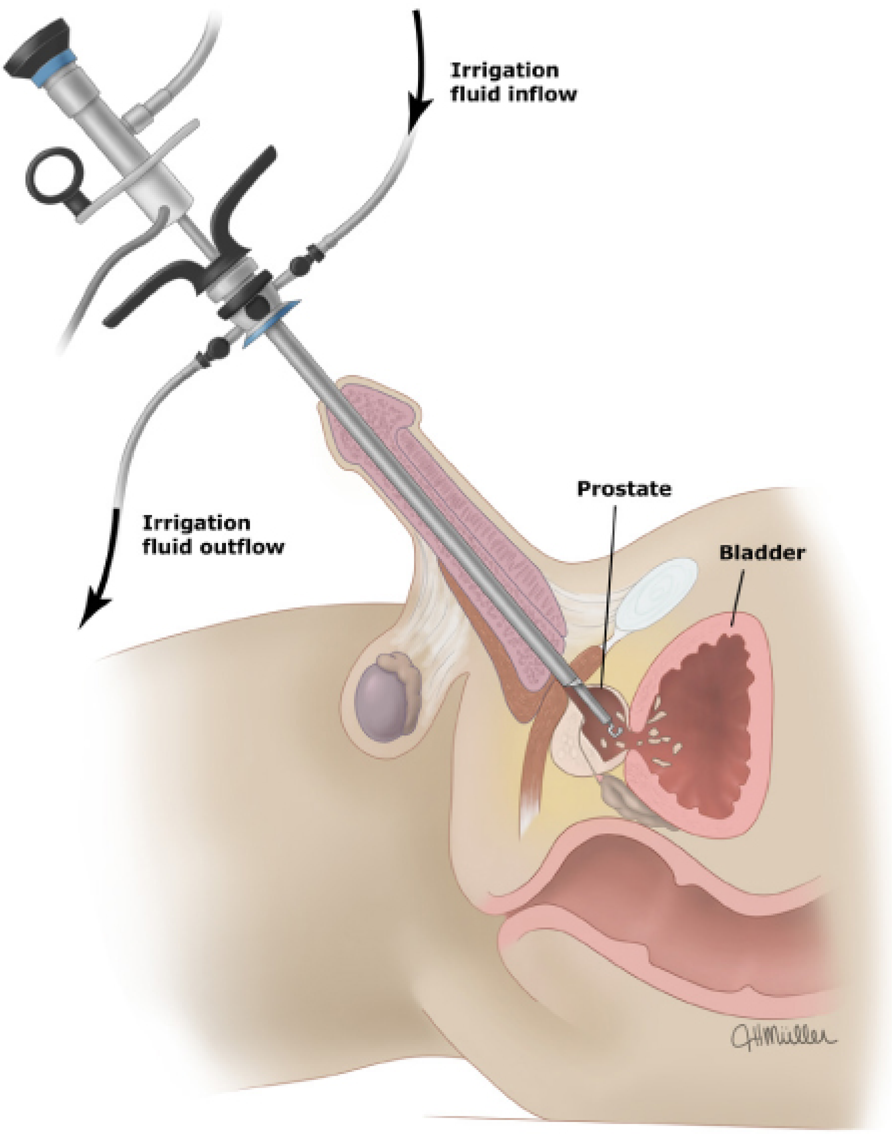
¶ RWT requires a prostate between 30 and 80 grams.

Δ PUL requires a prostate between 30 and 80 grams that is free of obstructing midline tissues.

◇ WVTT requires a prostate between 30 and 80 grams.

Graphic 127383 Version 2.0

Transurethral resection of the prostate (TURP)

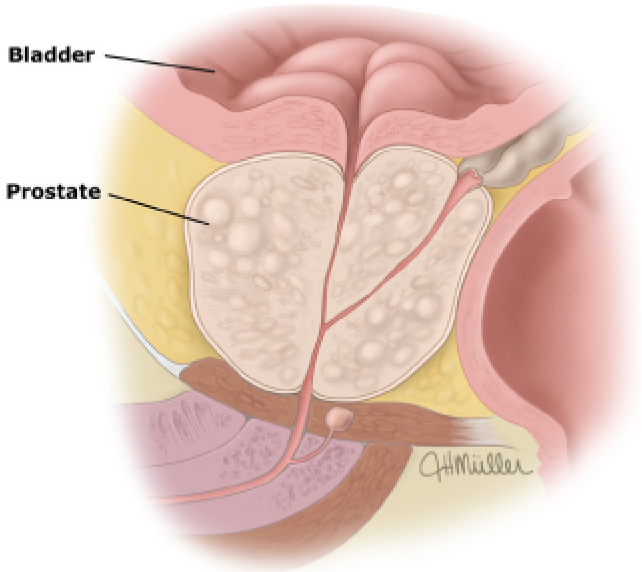


A resectoscope loaded with a diathermy loop is introduced into the bladder. Under direct vision, strips of prostatic adenoma are resected one at a time and dropped into the bladder. After the entire adenoma is resected, the prostate chips are evacuated from the bladder and hemostasis is achieved with electrocautery.

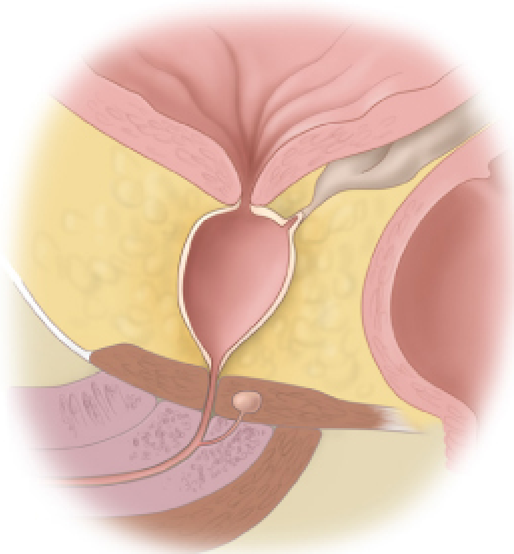
Graphic 72119 Version 1.0

Prostate anatomy after transurethral resection

BEFORE TURP



AFTER TURP

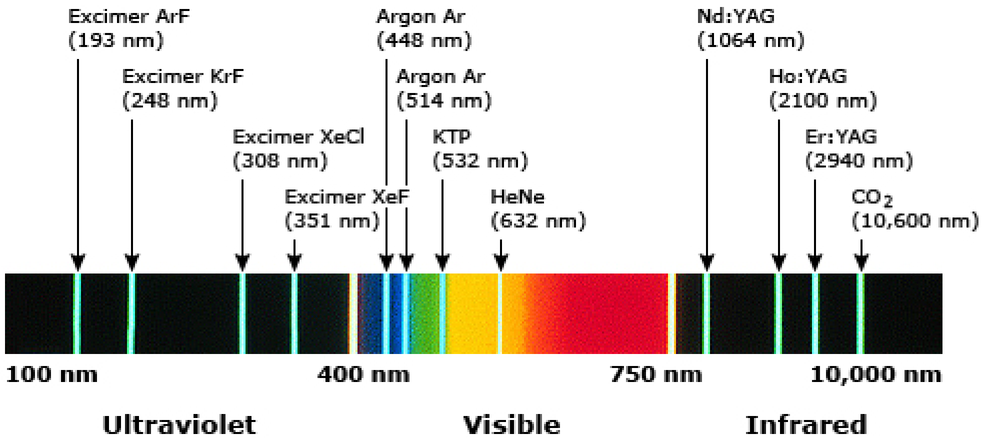


Following TURP, the prostatic fossa is bound only by its capsule. The cavity will become lined with a regenerated surface in 6 to 12 weeks.

TURP: transurethral resection of the prostate.

Graphic 58306 Version 4.0

Electromagnetic spectrum and medical laser wavelengths



Graphic 59189 Version 5.0

Contributor Disclosures

Kevin T McVary, MD, FACS Patent Holder: Thermal-Activated Penile Prosthesis [Erectile dysfunction]. Grant/Research/Clinical Trial Support: Boston Scientific [Benign prostatic hyperplasia];MedeonBio [Benign prostatic hyperplasia];Urovant [Overactive bladder]. Consultant/Advisory Boards: Antares[Voiding dysfunction];Boston Scientific [Benign prostatic hyperplasia]. All of the relevant financial relationships listed have been mitigated. **Michael P O'Leary, MD, MPH** No relevant financial relationship(s) with ineligible companies to disclose. **Wenliang Chen, MD, PhD** No relevant financial relationship(s) with ineligible companies to disclose.

Contributor disclosures are reviewed for conflicts of interest by the editorial group. When found, these are addressed by vetting through a multi-level review process, and through requirements for references to be provided to support the content. Appropriately referenced content is required of all authors and must conform to UpToDate standards of evidence.

Conflict of interest policy

→