Techniques in Vascular and Interventional Radiology

Benign Prostatic Hyperplasia: Clinical Manifestations, Imaging, and Patient Selection for Prostate Artery Embolization

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Prostate artery embolization (PAE) has been shown to be safe and effective at treating lower urinary tract symptoms (LUTS), urinary retention, and hematuria caused by benign prostatic hyperplasia (BPH). To distinguish from other causes of these symptoms, a multidisciplinary evaluation by a urologist and interventional radiologist should include a complete history to screen for any nonprostate causes of LUTS. The International Prostate Symptom Score is a useful objective measure to quantify the patient's urinary complaints. A physical exam should be performed to evaluate a patient's candidacy for angiography, and baseline laboratory evaluation should ensure that the patient's coagulation and kidney function are adequate. In certain situations, patients may benefit from cystoscopy and urodynamic evaluation to ensure their symptoms are related to BPH. A review of the patient's imagining can be the most important component of the evaluation of a patient prior to PAE, because a patient's gland size is often a primary driver of what procedural options available are to him. Men with small glands (≤30 mL) can be treated with several of the available minimally invasive transurethral procedures, but larger glands (≥80-120 mL) may be limited to holmium laser enucleation of prostate, thulium laser enucleation of prostate, surgical prostatectomy, or PAE, depending on institutional practice patterns. Secondary considerations include medical comorbidities, the risks for sexual side effects, the risk for bleeding, and the possible adverse events associated with the procedure, which are all low for PAE. Most patients suffering from symptomatic BPH resulting in LUTS, retention, or hematuria will benefit from PAE.

KEYWORDS Embolization, prostate, benign prostatic hyperplasia (BPH), lower urinary tract symptoms (LUTS), retention, hematuria

Clinical Manifestiations of Benign Prostatic Hyperplasia

As men age, overgrowth of the transitional zone of the prostate can result in symptomatic benign prostatic hyperplasia (BPH). The prevalence of histologic BPH increases with age from 8% in men in the fourth decade of life to over 80% in those over 80-year old.[1] As the prostate enlarges, urethral impingement can lead to progressive bladder outlet obstruction resulting in a spectrum of manifestations from mild lower urinary tract symptoms (LUTS) to complete urinary retention. Additionally, the hyperplastic prostatic tissue is often friable, which can lead to recurrent

Abbreviations: BPH, Benign prostatic hyperplasia; LUTS, lower urinary tract symptoms; PAE, prostate artery embolization; IPSS, International Prostate Symptom Score; QoL, quality of life; PVR, post void residual; PSA, prostate specific antigen; CBCT, cone-beam CT; TURP, transurethral resection of prostate; PVP, photoselective vaporization; PUL, prostatic urethral lift, TUMT, transurethral microwave thermotherapy; WAVE, water vapor energy ablation; TUIP, transurethral incision of prostate; HoLEP, holmium laser enucleation of prostate; ThuLEP, thulium laser enucleation of prostate; SIR, Society of Interventional Radiology

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and even life-threatening gross hematuria. Each of these conditions — LUTS, urinary retention, and recurrent hematuria — can be treated effectively and safely with prostate artery embolization (PAE).[2,3]

BPH primarily results in a set of symptoms known collectively as LUTS. These symptoms are often categorized as either storage or voiding in nature. Experienced during urination, voiding symptoms such as weak stream, intermittency, hesitancy, dysuria, straining, incomplete emptying, and terminal dribble are obstructive in etiology. These can be distinguished from storage symptoms such as urgency, frequency, and nocturia, which can also be related to an overactive bladder. Most men experience a combination of voiding and storage symptoms, and these symptoms may progress over a period of years. The Health Professionals Follow-up Study described the progression of symptomatic BPH, finding that men transitioned to severe LUTS at a rate of 44.9 new cases per 1000 patient-years, and that the progression rate rose sharply as men aged.[4] Early on, LUTS can be distressing and lead to sexual dysfunction, severe sleep disturbances, depression, and decreased ability to perform activities of daily living.[5] As voiding becomes more difficult and postvoid residuals worsen, the risks of urinary infection, bladder stone formation, and hydronephrosis increase. Because of these effects on morbidity and quality of life, many men with LUTS seek treatments ranging from medical therapy to total prostatectomy in search of relief.

Outlet obstruction can further progress from LUTS to complete urinary retention, another common sequela of BPH. In these patients, the rate of developing acute urinary retention has been found to be 0.4%-6.6% per year.[6] Furthermore, after 1 episode of retention, over two-thirds of men will have at least 1 recurrence of retention within a year.[7] Acute urinary retention presents as suprapubic discomfort and an inability to urinate, but chronic urinary retention is often painless and may go unnoticed for some time. Chronic or recurrent acute urinary retention can contribute to additional problems. First, recurrent retention can lead to progressive worsening of bladder detrusor function as well as renal impairment. Second, men who fail voiding trials require either intermittent self-catheterization or a chronic indwelling urinary catheter. While inconvenient and emotionally distressing, catheters also leave the patient vulnerable to urethral trauma and recurrent urinary tract infection. Although data on rates of infection from chronic catheterization in the outpatient population are sparse, inpatient rehabilitation patients with higher levels of care develop 2.9-3.2 catheter associated urinary tract infections per 1000 catheter-days.[8]

BPH is also 1 of the leading causes for gross hematuria in men. As the prostate gland adenomatous tissue enlarges, it can become prone to bleeding. Mild and intermittent hematuria may require no treatment at all. However, moderate hematuria can progress to clot retention requiring catheterization and continuous bladder irrigation, and severe hematuria can require intensive care unit admission, blood transfusion, and even progress to life-threatening hemorrhage.[9] Conservative management with 5-alpha-reductase inhibitors and irrigation often fail, necessitating surgical intervention.

Patient Evaluation and Diagnostic Imaging

Patient History

Evaluating patients for PAE should always be a coordinated effort between a urologist and an interventional radiologist. Although BPH is the most common cause of LUTS and urinary retention in male patients, a patient presenting with urinary symptoms and seeking treatment must be evaluated for the many other possible causes of these symptoms besides an enlarged prostate. Voiding symptoms can also be caused by urethral stricture, bladder neck contracture, prostate cancer, passing stones, or meatal stenosis. Storage symptoms can be caused by overactive bladder, urinary infection, radiation cystitis or prostatitis, noninfectious chronic prostatitis, bladder stones, or bladder cancer. Neurological problems including spinal cord injury, Parkinson's disease, multiple sclerosis, and detrusor-sphincter dyssynergia can manifest with mixed symptoms. Furthermore, BPH-related bladder outlet obstruction can coexist with any of these other conditions, sometimes making evaluation of symptoms challenging. Evaluation should be comprehensive to exclude these conditions, as PAE or any other BPH procedural treatment is unlikely to help patients with nonobstructive pathologies. Accordingly, any patient seeking procedural treatment for BPH should be evaluated in a multidisciplinary fashion.

When evaluating a patient with LUTS, a complete history should be obtained including an assessment of the patient's subjective voiding and storage urinary symptoms. In order to quantity the patient's symptoms as well as their effect on his quality of life, every patient presenting with LUTS should complete the International Prostate Symptom Score (IPSS) questionnaire (Fig. 1).[10] The IPSS questionnaire has been extensively validated and widely adopted as a standard component of a patient's voiding history. The questionnaire asks the patient to numerically grade how frequently he experiences symptoms of incomplete emptying, frequency, intermittency, urgency, weak stream, straining, and nocturia from 0 ("not at all") to 5 ("almost always") (Fig. 1). These scores can help differentiate if the patient has symptoms primarily with voiding or storage, and can thus focus the differential diagnosis, further workup, and treatment. The total score is then used to stratify a patient's symptom burden, where a score of 1-7 is defined as mild, 8-19 as moderate, and 20-35 as severe. A final question asks the patient to grade his quality of life (QoL) from delighted (scored as 0) to terrible (scored as 6; Fig. 1). The IPSS and QoL scores are an important baseline metric to obtain for each patient, as the scores can then be tracked over time to monitor symptom improvement after a medical or procedural intervention. Patients in retention who require an indwelling catheter or intermittent self-catheterization cannot by definition provide an IPSS or QoL score.

International Prostate Symptom Score (IPSS)	Not at all	Less than 1 time in 5	Less than 1/2 the time	About 1/2 the time	More than 1/2 the time	Almost Always
Incomplete Emptying During the last month, how often have you had a sensation of not emptying your bladder completely after you finished urinating?	0	1	2	3	4	5
Frequency During the last month, how often have you had to urinate again less than 2 hours after you finished urinating?	0	1	2	3	4	5
Intermittency During the last month, how often have you found you stopped and started again several times when you urinated?	0	1	2	3	4	5
Urgency During the last month, how often have you found it difficult to postpone urination?	0	1	2	3	4	5
Weak Stream During the last month, how often have you had a weak urinary stream?	0	1	2	3	4	5
Straining During the last month, how often have you had to push or stain to begin urination?	0	1	2	3	4	5
Nocturia During the last month, how many times did you most typically get up to urinate at night?	None 0	1 Time 1	2 Times 2	3 Times 3	4 Times 4	5 Times 5

Total Prostate Symptom Score = _____ *Severity:* *1-7 = mild* *8-19 = moderate* *20-35 = severe*

Quality of Life (QoL)	Delighted	Pleased	Mostly Satisfied	Mixed	Mostly Dissatisfied	Unhappy	Terrible
If you were to spend the rest of your life with your prostate symptoms just as they are now, how would you feel about that?	0	1	2	3	4	5	6

Figure 1 International Prostate Symptom Score (IPSS) and Quality of Life (QoL) questionnaire.[10]

Gross hematuria is a common sequela of BPH, and can even at times be the primary indication for embolization, for example, when exacerbated by anticoagulation medications. Common causes of hematuria include BPH, urinary infection, catheter trauma, stone disease, upper or lower urinary tract tumor, and trauma. Careful evaluation of risk factors for such etiologies is important to either rule out or treat any problems that may be more urgent than BPH. Thorough documentation of a prostatic etiology for gross hematuria is also important if it is the indication for embolization, as many insurance providers will currently only provide coverage for PAE when performed as a means to control hemorrhage.

Additionally, a thorough documentation of any prior urological procedures, current or prior medications including BPH medications and their efficacy, as well as sexual history including erectile function assessment is necessary. It is important to understand what prior procedures a patient may have had to treat BPH, why the patient's symptoms have returned and if the recurrent symptoms are indeed related to treatment failure. A medication history that includes sympathomimetics, antidepressants, antipsychotics, antiarrhythmics, anticholinergics, or antiparkinsonian drugs could suggest that the patient's symptoms are side effects of a medication, which should prompt consideration of dose reduction or alternatives. Furthermore, an overall assessment of the patient's nonurological medical and surgical history is important for subsequent risk stratification and counseling if a patient is considered a candidate for PAE. As opposed to most surgical procedures, PAE can generally be done as an outpatient procedure with minimal-to-no sedation through a small arteriotomy, in patients who would otherwise be poor surgical candidates due to medical co-morbidities.

Physical Exam

When establishing candidacy of a patient for a PAE procedure, the physical exam plays an important role. An airway assessment and cardiopulmonary exam will give an

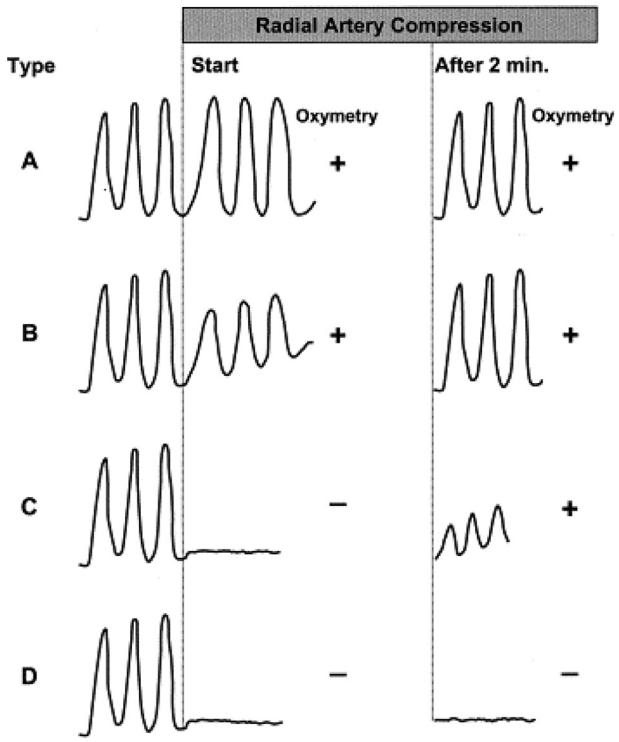

Figure 2 Barbeau test. A pulse oximeter is placed on the patient's thumb or index finger, the radial artery is occluded, and note is made of the ulnar artery oximetry saturation and waveform for up to 2 minutes. There are 4 types of responses: (A) no change in waveform or saturation, (B) damping of the waveform, (C) initial loss of the waveform and saturation with recovery, and (D) loss of the waveform and saturation without recovery. Barbeau type D is the only true contraindication to transradial access. [Figure reprinted from Barbeau et al.[11]

indication about whether the patient will tolerate moderate or light sedation. The patient should also be laid supine to ensure that he will be comfortable enough lying on the procedure table. A complete pulse exam is necessary to establish any baseline vascular disease and for vascular access planning. This includes a Barbeau test to assess for adequate ulnar collateralization of flow to the hand when considering radial arterial access (Fig. 2), which is typically performed from the left.[11,12] Some practitioners will avoid radial arterial access if a patient is taller than 72 inches, due to the possibility that currently available angiographic catheters may not be long enough to reach the prostatic arteries. A thorough genital exam is important to document any pre-existing skin discolorations or other lesions that could be potentially confused for postprocedure nontarget embolization complications. If the patient has an indwelling catheter in, this too should be examined for any evidence of infection, poor positioning, or skin erosion. A rectal exam does not typically add much to the evaluation for PAE, as it is at best a rough measure of gland volume, and has greater value in screening for prostate cancer and is best performed by a urologist.

Laboratory Evaluation

Routine preprocedure labs include a complete blood count without differential to establish the patient's baseline hemoglobin and hematocrit. Platelet concentration and coagulation panel including INR are obtained to screen for postprocedure bleeding risk. A basic metabolic panel including serum creatinine is used to assess renal function prior to contrast administration. If there is concern for urinary tract infection, and in any patient with high postvoid residual or indwelling urinary catheter, a urinalysis and culture should be obtained. After shared decision-making, the prostate specific antigen (PSA) level can be used to screen for prostate cancer, although one should be aware that PSA also increases with increasing glandular volume and that some men with prostate cancer will have a normal PSA.

Imaging Evaluation

Review of any cross-sectional imaging the patient may have had in the preceding 12 months is satisfactory for gross evaluation of prostate gland volume and morphology. If no prior imaging is available, transabdominal ultrasound is a widely available and inexpensive method to evaluate the prostate. Transrectal ultrasound, while more invasive, offers improved resolution of the gland. Indeed, the American Urologic Association guidelines on BPH recommend consideration of pretreatment ultrasound for 2 reasons. First, it allows for assessment of prostate gland size and shape. Second, it allows for obtaining postvoid residual measurements.[13] Although postvoid residual has not been shown to correlate with degree of LUTS, it is important for assessing the patient's baseline bladder function, and for follow-up after PAE to assess for improvement.

Pelvic magnetic resonance imaging (MRI) is the gold standard for measuring segmented prostate gland volume, and it is also useful for characterizing adenomatous prostate tissue and for prostate cancer screening. Recently, a small case-control study demonstrated that patients with adenomatous-dominant BPH had better outcomes after PAE than matched patients without adenomatous-dominant glands. Specifically, the authors showed that patients with hypervascular macronodules surrounding the hyperplasic central gland had a larger reduction in prostate volume and more robust improvements in IPSS scores.[14] Thus, MRI could become a useful tool for predicting which patients will respond better to PAE.

Preprocedure noncontrast computed tomography (CT) usually adds little to the ultrasound or MRI evaluation of the prostate gland itself. However, some authors prefer to obtain preprocedure pelvic CT angiograms (CTA) to assess the degree of iliofemoral atherosclerosis and the prostatic arterial anatomy for planning purposes, and there are some data to suggest that such a scan can reduce procedure time. However, in our practice, many patients have borderline renal function making additional contrast use risky, and we do not find that preprocedural CTA significantly alters our decision to treat or our procedural efficiency when performing PAE. Instead, we routinely perform intraprocedural cone-beam CT (CBCT) during selective prostatic artery contrast injection. First, CBCT can give a more accurate baseline gland volume than can ultrasound, providing an up-to-date gland volume at the time of embolization. Second, CBCT with an intra-arterial contrast bolus can also more effectively show

collateral flow to potential sites of nontarget embolization, which need to be addressed prior to preceding with embolization.

A preprocedure CT urogram is standard of care for those patients being worked up for gross hematuria. Specifically, the CT urogram includes an unenhanced scan, a nephrographic phase scan (~100-second delay), and an excretory phase scan (~8-minute delay) to assess for upper tract pathology including stones, renal masses such as renal cell carcinoma, and urothelial thickening that may signal transitional cell carcinoma. The workup of gross hematuria also includes cystoscopy to assess for lower tract pathology.

Cystoscopic Evaluation

All patients with gross hematuria should undergo cystoscopy by a urologist to evaluate for sources of bleeding. Cystoscopy can identify bladder tumors as well as bladder calculi that may have gone undetected on the CT urogram. If the source of the patient's hematuria is found to be benign prostate tissue without obvious evidence of cancer, the urologist may proceed with fulguration of the bleeding tissue or even transurethral resection if conservative therapy with a 5-alpha-reductase inhibitor or bladder irrigation has not worked. In some cases, the hematuria is intractable, despite aggressive transurethral management. The patient may return to the urology clinic or emergency department many times with recurrent gross hematuria, posing a challenge for the urologist to manage. Such a clinical scenario may prompt a referral for PAE.

For patients with LUTS, cystourethroscopy should always be considered to evaluate for anatomical reasons for symptoms other than an enlarged prostate. Urethral strictures, bladder neck contractures, bladder stones, and even bladder cancers can be found and treated this way. In these cases, PAE should only be carefully considered once the degree of symptomatology related to obstructive prostate tissue has been determined. Understanding the size and morphology of the gland (median lobe hyperplasia, lateral lobe impingement, or trilobar hyperplasia) is important to appropriately counsel the patient about transurethral procedural options, as some procedures will be precluded by gland size larger than 80 mL or an enlarged median lobe. Some of these features can also be assessed with imaging (Fig. 3). While enlarged glands or obstructing median lobes may affect the surgical approach, these factors have not been shown to affect outcomes of PAE.[15]

Urodynamic Evaluation

Finally, a complete workup of LUTS may include urodynamic evaluation. Uroflowmetry is a noninvasive urodynamic assessment whereby a patient urinates into a device that measures volume of urine produced per unit time. Maximal flow rates <10 mL/sec are suggestive of possible bladder outlet obstruction. Although an excellent screening tool, a diagnosis of bladder outlet obstruction cannot be ruled in based on uroflowmetry alone, as a low flow rate can also be seen with strictures or poor bladder function. A multichannel urodynamic study with cystometry, electromyography, and pressure-flow studies is the gold-standard for evaluating LUTS.[16] As this test involves invasive catheterization, it is usually only performed to determine the etiology of a patient's symptoms when they are equivocal or atypical. If there is a high index of suspicion for poorly functioning detrusor muscle, particularly in conditions such as multiple sclerosis, Parkinson's disease, spinal cord injury, or diabetes mellitus, a urodynamic study can further elucidate this. When properly interpreted, these studies can add data to the evaluation of a patient with LUTS, but invasive urodynamic studies are often unnecessary for the majority of BPH patients.

Patient Selection

Patients diagnosed with symptomatic BPH should initially undergo a trial of medical therapy for 3-6 months before invasive therapies are considered. The first-line drug for BPH is a long-acting alpha-1-adrenergic antagonist (tamsulosin, terazosin, doxazosin, alfuzosin, or silodosin). These have been shown to improve IPSS scores by 30%-40% and increase urine flow rates by 16%-25%.[17] However, common side effects of these medications include orthostatic hypotension, dizziness, ejaculatory dysfunction, and headache, which cause men to discontinue these medications at a rate as high as 10%.[17] For those who do not tolerate alpha-1-adrenergic antagonists or who require additional therapy, a 5-alpha-reductase inhibitor (finasteride or dutasteride) is commonly used in combination therapy. Because they work by

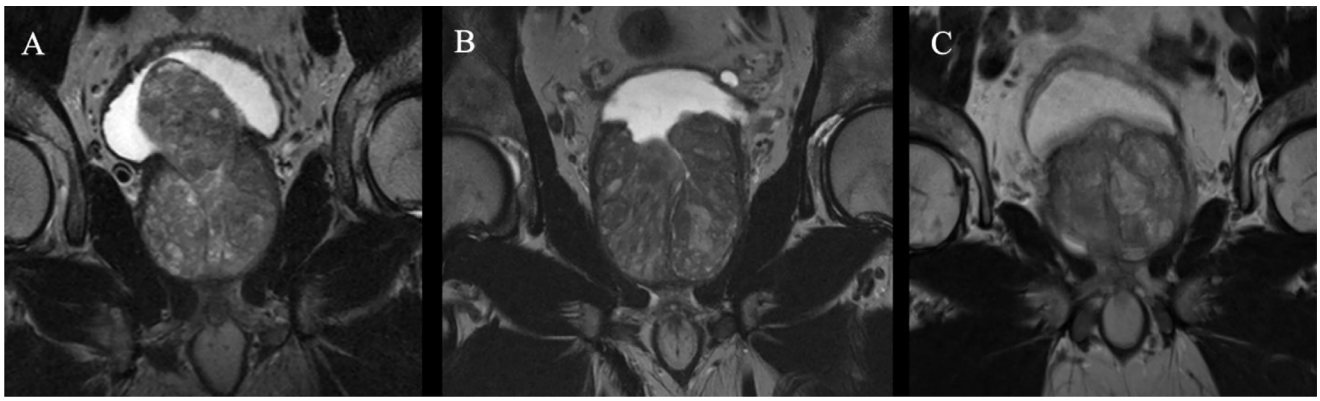

Figure 3 Coronal T2 MR images of 3 different patients demonstrating (A) median lobe enlargement, (B) lateral lobe enlargement, and (C) trilobar enlargement.

reducing the size of the gland, 5-alpha-reductase inhibitors may be more effective in larger prostates, but they may take several months to reach full effect. They are less effective at reducing IPSS as the alpha-1-adrenergic antagonists, with reported improvements in IPSS of around 15%.[18] Side effects of 5-alpha-reductase inhibitors include erectile dysfunction, decreased libido, and depression. Phosphodiesterase-5 inhibitors (tadalafil) are another therapeutic option for men with erectile dysfunction and symptoms of BPH, but are not superior to alpha-1-adrenergic antagonists and have not shown benefit when used as dual therapy with alpha-1-adrenergic antagonists or 5-alpha-reductase inhibitors. Anticholinergics (tolterodine, oxybutynin, darifenacin, solifenacin, fesoterodine, or trospium) can help patients with predominantly storage symptoms, but side effects including dry mouth, blurry vision, drowsiness, tachycardia, constipation, and decreased cognition limit tolerability. Importantly, medical therapy is seldom sufficient for men with severe symptoms (IPSS ≥ 20) and many men with moderate symptoms will fail medical therapy as well.

For those who fail or decline medical management, or for those who have problems such as refractory urinary retention or recurrent gross prostatic hematuria, PAE is 1 of many procedural options available to treat the symptoms of BPH. In terms of symptomatic improvement and improved flow rates, the current gold standard of minimally invasive transurethral procedures is the transurethral resection of the prostate (TURP). Other minimally invasive options include photoselective vaporization, prostatic urethral lift, transurethral microwave thermotherapy, water vapor energy ablation, and transurethral incision, which are generally are less invasive with improved side effect profiles, but often at the cost of lower efficacy. For larger glands, simple open or laparoscopic prostatectomies are effective but invasive options. Transurethral holmium and thulium laser enucleation are emerging transurethral techniques that can also be used for large glands. Overall, selection of the optimum procedure for a patient must take into account gland size, patient medical comorbidities, the potential for sexual side effects, and the risk for complications including bleeding.[13]

The primary consideration when determining treatment options is a patient's gland size. The size of the prostate is classically defined as small (≤30 mL), average (30-80 mL), or large (≥80-120 mL). The term "large" is not precisely defined in urologic guidelines and will vary by institution and urologist.[13] Prostates defined as large are usually those ≥80 mL, the size at which many transurethral procedures become challenging or less effective. Patients with small glands can be treated with most modalities, but as the gland size increases, the options become increasingly limited. Men with glands >30 mL may not be candidates for transurethral incision. Men with glands >80 mL are not candidates for prostatic urethral lift or water vapor energy ablation. Patients with glands >100-120 mL are generally not candidates for any minimally invasive transurethral procedure, and must then consider surgical prostatectomy or a transurethral enucleation, although such procedures are only available at select institutions. PAE has been found to be safe and effective at any gland volume and has been performed successfully with good outcomes in glands larger than 500 mL (Fig. 4).[19]

Secondary considerations when deciding on a procedural treatment plan for a BPH patient include medical comorbidities, the risks for sexual side effects, and the risk for bleeding. The majority of transurethral procedures require general or spinal anesthesia. However, PAE is typically performed with moderate sedation or even with no sedation at all, which poses fewer risks for patients with significant cardiopulmonary comorbidities.[20] Patients may also be concerned about their sexual function after treating their symptomatic BPH, and indeed many of the transurethral treatments carry risks of erectile dysfunction or retrograde ejaculation.[20] Fortunately, PAE has not been shown to have any adverse effects on erectile or ejaculatory function, although semen volume and viscosity tend to decrease after

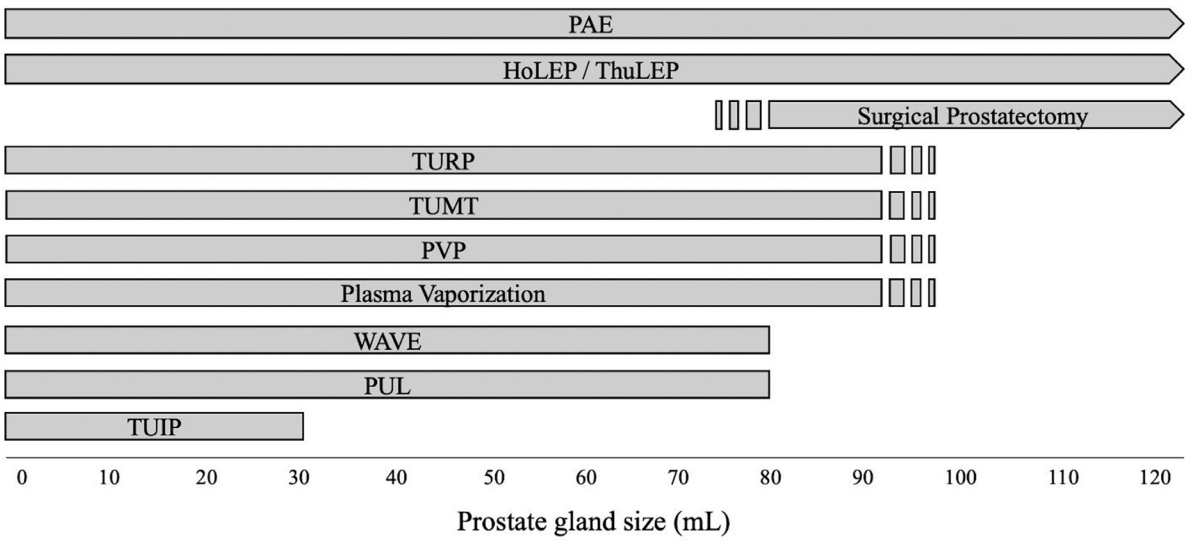

Figure 4 Procedural options for different sized prostate glands. TUIP should only be performed for glands ≤ 30 mL. WAVE and PUL are only approved for glands up to ≤ 80 mL. The upper limit for TURP, TUMT, PVP, and plasma vaporization will depend on urologist experience, but they are usually not suited for large glands. Although surgical prostatectomy is effective at any gland size, it is only considered in large glands because of its invasiveness. HoLEP, ThuLEP, and PAE are effective at any gland size.

embolization. Additionally, many transurethral procedures and all of the more invasive enucleation or prostatectomy procedures carry risks of bleeding. For example, a meta-analysis of outcomes following TURP found a 0%-9% risk of bleeding necessitating blood transfusion.[21] No such bleeding risks are associated with PAE.

As a final consideration, the side effect profiles of available treatment options should be considered when selecting a procedural treatment. In a meta-analysis of 662 patients, PAE was shown to be safe with only 2 Society of Interventional Radiology class C adverse events (requiring therapy and minor hospitalization <48 hours). There were no Society of Interventional Radiology class D (major therapy, > 48-hour hospital stay), class E (permanent adverse sequelae), or class F (death) adverse events.[2] The most commonly described complications of PAE are acute transient urinary retention (7.85%), urinary tract infection (3.17%), rectalgia and/or dysuria (9.06%), transient hematuria (4.38%), transient hematospermia (3.63%), and transient rectorrhagia (3.02%).[2] These resolve with minimal or no intervention. By comparison, TURP carries a small but significant risk of intraoperative complications including blood loss requiring transfusion (2%) and transurethral resection syndrome (0.8%), a spectrum of complications due to absorption of irrigation fluid during TURP. Postoperative complications of TURP include clot retention (4.9%), urinary retention (4.5%), hematuria (3.5%), and urinary infection (4.1%). Further, there are late complications associated with TURP such as bladder neck stenosis (2%) and urethral stricture (4.1%), which can require additional surgical intervention. These have not been described after PAE.[23]

CONCLUSION

In summary, many patients suffering from symptomatic BPH resulting in LUTS, retention, or hematuria can benefit substantially from PAE. Though BPH is often the primary cause of these symptoms, one must ensure that the prostate is actually the source of the problems before a procedure such as PAE is undertaken. For this reason, co-management with the patient's urologist and a complete evaluation are critical to establish the correct diagnosis. After alternative etiologies are excluded by a combination of history, physical exam, a review of imaging studies, cystoscopy, and urodynamics, an informed treatment plan can be formulated. The patient's gland size will often dictate the procedural options available to him, in addition to the patient's operative risks and his wishes regarding sexual function preservation. Patients with large glands have fewer options including surgical prostatectomy, PAE, or holmium laser enucleation of prostate/thulium laser enucleation. For those with medical comorbidities that preclude anesthesia or invasive surgery, those with high risks of bleeding, those who wish to preserve sexual function, or those who desire the least invasive available procedure, PAE is a safe and effective treatment option.

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