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Mini-Review

Urology

Prostate Artery Embolization: Long-Term Outcomes and Selection for High-Risk Surgical Patients

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Abstract

Prostate artery embolization has emerged as a minimally invasive treatment for lower urinary tract symptoms secondary to benign prostatic hyperplasia. While transurethral resection of the prostate remains the reference standard, this procedure offers a compelling alternative for patients who are poor surgical candidates or who prioritize preservation of sexual function. This mini-review synthesizes the current evidence on long-term durability and delineates patient selection criteria, with particular emphasis on non-surgical candidates. Data from large cohort studies randomized controlled trials, systematic reviews, and multisociety consensus statements are reviewed. The technique demonstrates sustained symptomatic improvement with acceptable reintervention rates and a favorable safety profile. It offers unique advantages in specific populations, including those with large prostates, urinary retention, coagulopathy, and advanced comorbidities.

Keywords: Prostate artery embolization, Benign prostatic hyperplasia, Lower urinary tract symptoms, Minimally invasive therapy, Patient selection

Introduction

Benign Prostatic Hyperplasia (BPH) is a highly prevalent condition affecting the majority of men over 50 years of age, with resultant Lower Urinary Tract Symptoms (LUTS) significantly impairing quality of life (Abt et al., 2021). The traditional surgical gold standard, Transurethral Resection of The Prostate (TURP), provides robust and durable symptom relief but carries risks of bleeding, urinary incontinence, ejaculatory dysfunction, and the need for general or spinal anesthesia (Abt et al., 2019; Bhatia et al., 2025). These risks are amplified in elderly patients with multiple comorbidities, those on anticoagulation therapy, and those with very large prostate glands.

Prostate Artery Embolization (PAE) was first described for the management of prostatic hemorrhage and subsequently adapted as a primary treatment for BPH-related LUTS (Abt et al., 2019; Bilhim et al., 2016). The procedure involves super-selective catheterization of the prostatic arteries via a femoral or radial approach under local anesthesia, followed by injection of embolic microspheres to induce prostatic ischemia and subsequent volume reduction (Abt et al., 2019). PAE is typically performed on an outpatient basis without the need for general anesthesia or transurethral instrumentation (Carnevale et al., 2020).

The American Urological Association (AUA) 2023 Guideline Amendment provides a conditional recommendation (Grade C evidence) that PAE may be offered for the treatment of LUTS/BPH (Bhatia et al., 2025). The Society of Interventional Radiology (SIR) Multisociety Consensus Position Statement further endorses PAE as an acceptable minimally invasive treatment option for appropriately selected men (Carnevale et al., 2020). This mini-

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review examines the long-term durability of PAE outcomes and the evidence-based criteria for patient selection, with a focus on non-surgical candidates.

Procedural Technique and Embolic Agents

PAE is performed via percutaneous arterial access, most commonly through the femoral artery, under local anesthesia and conscious sedation (Abt et al., 2019). Preprocedural Computed Tomography Angiography (CTA) or magnetic resonance angiography (MRA) is recommended to evaluate pelvic arterial anatomy and confirm the feasibility of prostatic artery catheterization (Abt et al., 2021; Dias et al., 2021). Digital subtraction angiography of the internal iliac arteries is performed to map the prostatic blood supply, followed by super-selective microcatheterization of the prostatic arteries (Abt et al., 2019).

Particle embolics are used almost exclusively, with microsphere sizes typically ranging from 100 to 500 µm (Abt et al., 2019). Commonly used agents include tris-acryl gelatin microspheres, polyvinyl alcohol (PVA) particles (both spherical and nonspherical), and calibrated microspheres (Abt et al., 2019; Franco et al., 2021). A 10-year single-center experience demonstrated that combined particle sizes (100–500 µm) did not significantly affect symptom recurrence rates compared with narrower size ranges (Jung et al., 2022). A recent Delphi consensus study involving 14 international experts has sought to standardize procedural techniques across six key domains, including embolic agent selection and strategies to prevent non-target embolization (Dias et al., 2021). Bilateral embolization is preferred, as unilateral PAE has been associated with significantly higher recurrence rates (42% vs. 21%) (Jung et al., 2022).

The integration of intraprocedural cone-beam CT (CBCT) has become a cornerstone of modern PAE, significantly improving the identification of complex prostatic arterial anatomy and reducing the risk of non-target embolization. Recent evidence also suggests that post-procedural MRI, specifically the calculation of the prostate necrosis rate, serves as a robust predictor of clinical success, with higher necrosis volumes correlating directly with symptom relief. According to the latest Delphi consensus, standardizing these imaging protocols is essential for achieving reproducible outcomes across centers.

Procedure times average 60–120 minutes, with fluoroscopy times of approximately 20–50 minutes (Bhatia et al., 2025). The procedure is technically demanding, and the AUA emphasizes that PAE should be performed only by clinicians specifically trained in this interventional radiology technique (Bhatia et al., 2025).

Long-Term Durability of Outcomes

Symptom relief and quality of life

The largest published cohort to date, comprising 1,075 patients with a mean follow-up of 458 days, demonstrated sustained and statistically significant IPSS improvement from a median baseline of 23 to 7 at 1–3 months, 6 at 6–12 months, and 9 at 48–60 months (P .001 at all time points) (McWilliams et al., 2019). Quality of life scores followed a parallel trajectory, improving from a median of 5 to 2, 1, and 2 at the same respective intervals. After PAE, 65.5% of patients were free of BPH obstruction medications at 1 year (McWilliams et al., 2019).

A 10-year single-center experience in 317 patients reported mean maximum IPSS improvement of 16 points, quality-of-life improvement of 4 points, prostatic volume reduction of 39% (39 cm^3), maximum urinary flow rate improvement of 155%, and postvoid residual volume reduction of 48% (Jung et al., 2022). Early clinical failure occurred in only 1.9% of patients, while symptom recurrence was observed in 23% at a median follow-up of 72 months. Notably, no patients in this cohort developed urinary incontinence or erectile dysfunction (Jung et al., 2022).

Reintervention rates

Reintervention rates represent a key consideration in evaluating PAE durability. In the 1,075-patient cohort, 16% of reintervention-eligible patients required a second prostatic intervention within 60 months (McWilliams et al., 2019). The Cochrane systematic review (2022) found that PAE likely increases retreatment rates compared with TURP in both the short term (RR 3.20, 95% CI 1.41–7.27; moderate-certainty evidence) and long term (RR 3.80, 95% CI 1.32–10.93; moderate-certainty evidence) (Abt et al., 2021). In the Swiss randomized trial, 21% of PAE patients required TURP within 2 years due to unsatisfactory outcomes (Pyrgidis et al., 2025).

These retreatment rates must be contextualized within the patient populations studied. Many PAE cohorts include patients with very large prostates and significant comorbidities who would otherwise have limited treatment options. Furthermore, in cases of clinical failure after PAE, patients retain the option of any urologic treatment or repeat PAE (Carnevale et al., 2020).

Comparison with TURP

Five randomized controlled trials (n = 352) have compared PAE with TURP, with substantial heterogeneity between trials (Bhatia et al., 2025). At intermediate-term follow-up (3–12 months), IPSS improvements were generally similar between groups, though the AUA Panel expressed uncertainty about the pooled effect (WMD 2.3 points, 95% CI −3.2 to 7.8) (Bhatia et al., 2025). At 24 months, one trial found similar IPSS changes between groups (MD 0.7 points), while another favored TURP (MD 2.9 points). TURP demonstrated superiority in objective measures including maximum urinary flow rate and postvoid residual volume (Bhatia et al., 2025; Pyrgidis et al., 2025). However, PAE was associated with fewer total adverse events, lower rates of urinary incontinence (RR 0.13, 95% CI 0.02–0.70), and significantly fewer ejaculatory disorders (Bhatia et al., 2025). A large German nationwide analysis of 3,665 PAEs, 218,388 TURPs, and 50,863 laser enucleations confirmed that PAE offers more favorable perioperative outcomes, including lower rates of in-hospital urinary retention and shorter hospital stays (Rostambeigi et al., 2026).

Beyond functional outcomes, PAE offers a distinct economic advantage through its reduced "hospital footprint". Large-scale analyses, such as the GRAND study, demonstrate that PAE is associated with significantly shorter hospital stays and lower rates of acute perioperative complications compared to both TURP and laser enucleation. This outpatient-centered approach not only improves patient satisfaction but also aligns with the global shift toward cost-effective, minimally invasive urological care.

Safety Profile

PAE has a favorable safety profile. Major complications are rare, occurring in less than 0.5–1% of patients across large series (Carnevale et al., 2020; McWilliams et al., 2019). In the 1,075-patient cohort, only seven patients (0.65%) experienced severe adverse events: transient ischemic attacks (n = 3), urosepsis (n = 2), and prostate sloughing requiring TURP (n = 2) all resolved without permanent sequelae (McWilliams et al., 2019). The SIR consensus statement identified only six major complications across more than 2,000 patients in 23 studies, including bladder

wall ischemia, severe urinary tract infection, rectal ulcers, and severe perineal pain (Carnevale et al., 2020).

Minor complications are more common and include postembolization syndrome (pain, dysuria, frequency), which typically resolves within one week (Carnevale et al., 2020). Perineal pain (9.4%), hematuria (9%), and transient acute urinary retention (7%) are the most frequently reported minor adverse events (Abt et al., 2019; Bilhim et al., 2016). Importantly, PAE avoids transurethral access, thereby eliminating the risks of urethral stricture, bladder neck stenosis, and TUR syndrome (Carnevale et al., 2020).

Sexual function preservation is a notable advantage. PAE does not appear to cause urinary incontinence or erectile dysfunction (Abt et al., 2019; Jung et al., 2022). Ejaculatory disorders are significantly less frequent after PAE compared with TURP (RR 0.51–0.67) (Abt et al., 2019; Bhatia et al., 2025).

Patient Selection Criteria

General Indications

The SIR Multisociety Consensus Position Statement provides the most comprehensive framework for PAE patient selection (Carnevale et al., 2020). PAE is recommended as an acceptable minimally invasive treatment option for men with BPH and moderate-to-severe LUTS (IPSS ≥ 13) who have failed or cannot tolerate medical therapy(Carnevale et al., 2020). The AUA 2023 Guideline Amendment conditionally recommends PAE following a discussion of potential risks and benefits (Bhatia et al., 2025).

Non-surgical candidates

PAE is particularly well suited for patients deemed poor surgical candidates. The SIR consensus identifies the following specific non-surgical populations: (Carnevale et al., 2020)

Advanced age and multiple comorbidities: Elderly patients with significant cardiovascular, pulmonary, or other systemic comorbidities who cannot tolerate general or spinal anesthesia are excellent PAE candidates. PAE requires only local anesthesia and conscious sedation and is performed on an outpatient basis (Carnevale et al., 2020).

Coagulopathy and anticoagulation/antiplatelet therapy: Patients who cannot safely discontinue anticoagulation or antiplatelet therapy represent a particularly underserved population for whom PAE offers a definitive treatment option (Carnevale et al., 2020).

Very large prostate glands (> 80 cm^3): PAE has no upper limit of prostate size, making it uniquely suited for patients with very large prostates who may not be candidates for TURP and would otherwise require open prostatectomy. Larger initial prostate volume has been identified as an independent predictor of clinical success after PAE (Carnevale et al., 2020; Franco et al., 2021; Sandhu et al., 2024; Wang et al., 2024).

Urinary retention with preserved bladder function: In the 1,075-patient cohort, 94% of catheter-dependent patients at baseline achieved catheter independence at 3 months. The SIR consensus supports PAE as a method of achieving catheter independence in patients with acute or chronic urinary retention (Carnevale et al., 2020; McWilliams et al., 2019).

Prostatic hematuria: PAE can be considered for patients with hematuria of prostatic origin as a method of achieving cessation of bleeding. The AUA Panel also recommends continued investigation of PAE for gross hematuria recalcitrant to other therapies (Bhatia et al., 2025; Carnevale et al., 2020).

Patients prioritizing sexual function preservation

PAE can be considered for patients who wish to preserve erectile and/or ejaculatory function (Carnevale et al., 2020). The absence of retrograde ejaculation and erectile dysfunction after PAE, compared with rates of 56–100% ejaculatory dysfunction after TURP, makes PAE an attractive option for sexually active men (Bhatia et al., 2025; Jung et al., 2022).

Predictors of success and contraindications

Several predictors of clinical success after PAE have been identified. Larger initial prostate volume, bilateral embolization, younger age (≤65 years), lower baseline IPSS, and the presence of acute urinary retention are associated with better outcomes (Franco et al., 2021; Jung et al., 2022; Sandhu et al., 2024; Wang et al., 2024). Higher prostate necrosis rates on 1-month post-procedural MRI and elevated PSA levels 24 hours after PAE (≥75 ng/mL) correlate with greater symptom improvement (Franco et al., 2021; Sandhu et al., 2024). Adenomatous-dominant BPH morphology is also associated with clinical success (Sandhu et al., 2024).

Relative contraindications include unfavorable prostatic arterial anatomy on CTA (tortuous or atherosclerotic vessels precluding catheterization), active urinary tract infection, and confirmed prostate malignancy(Abt et al., 2021; Bhatia et al., 2025; Carnevale et al., 2020). Extensive atherosclerotic disease may render the procedure technically infeasible (Carnevale et al., 2020).

Emerging Directions

Recent developments include the use of cone-beam CT guidance to improve prostatic artery identification and reduce non-target embolization (Bilhim et al., 2016; Yin et al., 2026).

In cases of extreme prostatic enlargement (>80 mL), a combined approach utilizing CBCT-guided PAE followed by TURP has emerged as a promising strategy. This hybrid technique leverages PAE to reduce perioperative vascularity and induce ischemia, followed by TURP to achieve immediate debulking. Emerging data indicate that this combination results in less intraoperative bleeding and shorter operative times compared to TURP alone for large-volume glands (Yin et al., 2026).

Emerging concepts such as liquid embolic agents and adjunctive coil occlusion techniques are under investigation. Standardization of procedural technique through expert consensus is an active area of development (Dias et al., 2021).

Conclusions

PAE is a safe and effective minimally invasive treatment for LUTS secondary to BPH, with demonstrated durability extending to 5–10 years in large cohort studies. While TURP remains superior in objective urodynamic measures and has lower retreatment rates, PAE offers comparable subjective symptom relief with a significantly more favorable safety and sexual function profile. PAE is particularly valuable for non-surgical candidates, including elderly patients with comorbidities, those on anticoagulation, patients with very large prostates, and those with catheter-dependent urinary retention. Optimal patient selection, bilateral embolization, and operator expertise are critical determinants of success. Continued investigation through multicenter randomized trials with long-term follow-up is warranted to further refine indications and establish the role of PAE within the evolving BPH treatment landscape.

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