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The role of endovascular therapy in the management of benign prostatic hyperplasia

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Abstract

Benign prostatic hyperplasia is a common condition in elderly men, often associated with lower urinary tract symptoms that negatively impact quality of life. The prevalence of benign prostatic hyperplasia is approximately 8% in men aged 30–40 years, but increases to up to 90% in those over 80 years old. Although current treatment options such as pharmacotherapy and endoscopic surgery have demonstrated high efficacy, surgical interventions still carry a risk of complications, particularly in elderly patients or those with multiple comorbidities. In recent years, prostatic artery embolization has emerged as a minimally invasive treatment modality, in which embolic agents are selectively injected into the prostatic arteries to reduce prostate volume and alleviate symptoms. Initial studies have shown that this endovascular technique offers significant symptom improvement, high treatment efficacy, fewer complications, shorter recovery time, and better quality of life. This review aims to present current medical evidence regarding the efficacy, safety, indications, and potential widespread application of endovascular intervention in the treatment of benign prostatic hyperplasia.

Keywords: Benign prostatic hyperplasia, lower urinary tract symptoms, prostatic artery embolization.

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1. INTRODUCTION

Benign prostatic hyperplasia (BPH) is one of the most common urological conditions in elderly men, closely associated with age-related hormonal changes and frequently leading to lower urinary tract symptoms (LUTS). These symptoms significantly impair quality of life, especially in cases of disease progression or poor response to medical therapy. Transurethral resection of the prostate (TURP) remains the gold standard for surgical treatment when medical management fails. However, it may not be suitable for elderly patients or those with multiple comorbidities due to the increased risk of perioperative complications. In response to this clinical need, prostatic artery embolization (PAE) has emerged as a minimally invasive alternative that improves symptoms and quality of life while minimizing complications. This review aims to provide insight into the current evidence on efficacy, safety, indications, and clinical applications of endovascular therapy for BPH.

2. REVIEWS

2.1. Definition

BPH is the uncontrolled and excessive proliferation of smooth muscle and epithelial cells within the transitional zone of the prostate. This condition commonly results

in LUTS in older men and may progressively worsen over time, significantly impacting patients' quality of life [1-3].

2.2. Clinical Symptoms

Irritative symptoms include nocturia, urgency, increased urinary frequency, and urinary incontinence. Obstructive symptoms include hesitancy, weak urinary stream, incomplete bladder emptying, and intermittency. The International Prostate Symptom Score (IPSS) and the Quality of Life (QoL) index are commonly used to assess the severity of LUTS and to evaluate clinical response after treatment.

IPSS is divided into three categories according to the total score. Patients with scores from 0 to 7 are classified as having mild symptoms, those with scores from 8 to 19 have moderate symptoms, and those scoring 20 to 35 are considered to have severe symptoms. This classification helps clinicians assess the severity of LUTS and guide appropriate management strategies for BPH.

2.3. Imaging Studies

Abdominal ultrasound: Abdominal ultrasound estimates prostate volume and post-void residual urine; it is non-invasive but less accurate than transrectal ultrasound [3,4].

Transrectal ultrasound (TRUS): TRUS precisely measures prostate volume, assesses intravesical extension, and guides biopsy or pre-intervention evaluation [3,4].

Multidetector computed tomography (MDCT): MDCT is not routine for BPH but helps assess prostate size and adjacent structures when other conditions are suspected [3,4].

Prostate magnetic resonance imaging (MRI): MRI provides detailed prostate anatomy, identifies intravesical protrusion, differentiates BPH from cancer, and evaluates post-treatment changes [3,4].

Cystoscopy: Cystoscopy allows direct visualization of the urethra and bladder, helping assess obstruction, rule out other LUTS causes, and detect diverticula or stones.

2.4. Treatment

2.4.1. Observation

This approach is suitable for patients with mild symptoms or those whose symptoms do not significantly impact their quality of life. Patients are advised to implement lifestyle modifications, such as limiting fluid intake, avoiding caffeine and alcohol, and performing pelvic floor muscle exercises [2,3,5].

2.4.2. Medical Therapy

Medical therapy is the first-line treatment for most patients with BPH, particularly those with mild to moderate symptoms. The commonly used medications include:

- Alpha-blockers (e.g., tamsulosin, alfuzosin, and doxazosin)
- 5-alpha-reductase inhibitors (5-ARIs) (e.g., finasteride and dutasteride)
- Phosphodiesterase-5 inhibitors (PDE5-Is) (e.g., tadalafil) [2,3,5].

2.4.3. Surgical Treatment

Surgery is indicated for patients with BPH who present with severe symptoms or complications, especially when medical therapy proves ineffective. There are three main surgical approaches:

Open Prostatectomy: Indicated for patients with significantly enlarged prostates, this procedure involves removing the entire inner portion of the prostate through an abdominal incision.

Transurethral Resection of the Prostate (TURP): TURP is the standard surgical treatment for BPH, removing obstructive tissue via the urethra to rapidly improve urinary flow. Common complications include retrograde ejaculation (65–75%), urethral stricture (2–10%), bladder neck contracture (0.3–9%), and urinary retention (5–6%). TUR syndrome occurs in about 1–2% of cases. Other possible issues are

erectile dysfunction, incontinence, infection, or bleeding. Mortality is rare (0–0.2%), and the overall complication rate is around 29%, mostly mild [6-8].

Laser Surgery: This technique uses laser energy to ablate prostatic tissue. It offers advantages such as reduced bleeding and shorter recovery time compared to TURP [2,3,5].

2.4.4. Endovascular Therapy: Prostatic Artery Embolization (PAE)

Mechanism of Action of PAE

PAE induces not only ischemic infarction but also activates multiple biological pathways, including programmed cell death (apoptosis) and disruption of the intrinsic innervation of the prostate [2,9,10]. The primary mechanisms include: Ischemia-induced infarction, apoptosis (programmed cell death), disruption of prostatic intrinsic neural pathways.

Indications

The indications for PAE in the treatment of BPH have not yet been fully standardized. However, according to Bilhim T. et al. (2016) [11], several clinical criteria may be considered for patient selection, including:

- Males over 55 years old.
- Confirmed diagnosis of BPH.
- Presence of moderate to severe LUTS:
  - IPSS ≥ 18
  - QoL score ≥ 3
- Failure to respond to medical therapy for ≥ 6 months or refusal of medical treatment.
- Maximum urinary flow rate (Qmax) ≤ 12 mL/s or presence of urinary retention.
- Prostate volume ≥ 30 mL.
- No evidence of neurogenic bladder or other severe voiding dysfunctions post-treatment.

Contraindications

Contraindications for PAE in the treatment of BPH include factors that may increase the risk of complications or reduce procedural efficacy. According to Bilhim T. et al. (2016) [11], the identified contraindications are as follows:

- Prostate cancer or other malignant pelvic tumors.
- Severe atherosclerosis or tortuosity of the internal iliac artery/prostatic artery, detected via pelvic vascular imaging (CT angiography).
- Secondary renal insufficiency due to lower urinary tract obstruction.
- Large bladder diverticula or presence of bladder stones.
- Neurogenic bladder.
- Loss of detrusor muscle function.
- Active urinary tract infection.
- Uncontrolled coagulopathy.

Embolization Technique in PAE

The procedure is performed under local anesthesia with DSA guidance:

- *Vascular access:* A catheter is introduced into the internal iliac artery via the femoral or radial artery, followed by angiography to identify the prostatic arteries.
- *Identification of prostatic arteries:* Selective angiographic techniques are used to locate and navigate a microcatheter into the appropriate branches of the prostatic arteries. Anteroposterior and oblique angiographic views are then obtained to assess for the presence of collateral branches. If collaterals are identified, the microcatheter must be advanced beyond the anastomosis to avoid non-target embolization.
- *Embolic particle injection:* Embolic particles are injected into the prostatic arteries to induce arterial occlusion, thereby reducing blood flow to the prostate. This leads to glandular shrinkage and alleviation of symptoms associated with benign prostatic hyperplasia.

The PErFecTED technique is a refined method of PAE developed to maximize prostatic devascularization through a two-phase embolization approach. After crossing any collateral branches, the microcatheter is first positioned proximally within the prostatic artery, and embolization is performed until near-stasis is achieved. The catheter is then advanced distally into the intraparenchymal branches (urethral and capsular groups) to complete arterial occlusion and achieve full stasis within the gland. Clinical evidence suggests that this two-step approach provides greater prostatic infarction and reduces symptomatic recurrence compared with simpler embolization techniques. Key technical considerations include the use of vasodilators to prevent vasospasm, slow and highly diluted injections to avoid premature proximal occlusion, and careful angiographic monitoring to minimize non-target embolization [12].

Embolic Material:

Polyvinyl Alcohol (PVA) Particles: PVA is a permanent, non-biodegradable embolic agent. Its mechanism of action involves adhering to the vessel wall, causing vascular occlusion through thrombus formation and subsequent fibrosis. Diluting PVA particles with heparin, normal saline, and contrast medium helps reduce viscosity and prevent microcatheter blockage. Although considered a permanent agent, PVA may be subject to recanalization due to neovascularization [13-15].

Microspheres: Microspheres are spherical embolic agents that allow for precise flow control and reduce the risk of non-target embolization. They are coated with a biocompatible polymer layer, which minimizes inflammation and enhances structural stability. These particles have uniform sizes (ranging from 40 to 900 μm) and are color-coded by diameter, facilitating visual identification and selection during the embolization procedure [13-15].

Other Embolic Agents: NBCA Glue (N-butyl-2-cyanoacrylate) is a biocompatible tissue adhesive used as a liquid embolic agent. When injected into the vasculature, NBCA rapidly polymerizes upon contact with blood, resulting in permanent vascular occlusion [13-15].

Currently, there is no universally optimal embolic agent for PAE. The choice between microspheres and PVA particles is made on a case-by-case basis, depending on individual patient characteristics. NBCA Glue is not yet widely used and its application largely depends on the operator's experience and the specific clinical context.

Procedure Efficacy

Endovascular treatment for BPH is a minimally invasive approach aimed at alleviating BPH-related symptoms. The effectiveness of PAE is assessed from two primary perspectives: technical efficacy and clinical efficacy [14,15].

Technical Efficacy:

- Technical success in PAE for the treatment of BPH is commonly defined by the ability to embolize at least one branch of the prostatic artery. According to Delazar et al, technical success is defined as successful embolization of at least one prostatic lobe during the procedure [16]. Similarly, Sapoval et al. also consider the procedure technically successful when at least one prostatic artery is embolized, although bilateral embolization is preferred to optimize clinical outcomes [15]. This criterion provides greater flexibility in clinical practice, particularly in cases with complex vascular anatomy or when bilateral access is technically challenging.
- Successful access and embolization of the prostatic arteries: Technical success depends on the ability to accurately

identify and catheterize the prostatic arterial branches via the vascular system. According to studies, the technical success rate ranges from 90% to 98% [11,16].

Clinical Efficacy:

- The clinical efficacy of PAE focuses on its ability to relieve LUTS, improve QoL, and enhance related clinical parameters such as the IPSS, prostate volume, and maximum urinary flow rate (Qmax).
- Reduction in LUTS: Numerous studies have reported a 40–60% reduction in IPSS within 6 months to 2 years following PAE, reflecting a significant improvement in urinary symptoms [17,18].
- Improvement in QoL: PAE leads to substantial improvements in patients' quality of life, typically reducing QoL scores by 1 to 2 points on the 0–6 scale. This improvement is often sustained for several years [11].
- Reduction in Prostate Volume: PAE typically reduces prostate volume by approximately 20–40%, thereby relieving urethral compression and improving urinary flow [19,20].
- Increase in Maximum Flow Rate (Qmax): Qmax typically improves by 30–50% post-procedure, helping alleviate symptoms such as hesitancy and increased urinary frequency [13].

These findings collectively underscore the high clinical efficacy of PAE as a viable treatment alternative for patients with moderate-to-severe BPH symptoms, particularly those unfit for surgery. The durability of symptom relief has been demonstrated in multiple long-term studies. For instance, Pisco et al. reported sustained clinical improvement in 81.9% of patients at 12 months, which remained as high as 78.8% after three years of follow-up [18]. Moreover, Iossa et al. emphasized that improvements in both objective measures (e.g., prostate volume, Qmax) and subjective outcomes (IPSS, QoL) persist in the majority of patients, with low complication rates and minimal impact on sexual function [21]. These results highlight PAE not only as a technically feasible intervention but also as a clinically effective and durable solution for BPH, aligning well with the growing demand for minimally invasive and patient-tailored therapies.

Complications

Although prostatic artery embolization (PAE) is considered a minimally invasive and safe treatment for benign prostatic hyperplasia (BPH), certain complications may still occur, most of which are mild and manageable. The overall complication rate ranges from 10% to 20%, with major complications being very rare (< 1%).

Common complications include [18]:

- Pelvic or perineal pain (#24,1%), typically occurring in the first few days post-procedure, related to ischemia in the targeted tissues. This is a frequently reported symptom.
- Transient urinary symptoms such as urgency, frequency, and incomplete voiding, often self-limiting (#23%).
- Mild hematuria, possibly due to urethral irritation or minor prostatic injury (#7,6%).

Less common complications [16,21]:

- Urinary tract infection or prostatitis, reported in approximately 2.5% to 4.6% of cases.
- Acute urinary retention, occurring in about 4.6% of patients.
- Non-target embolization, affecting adjacent arteries such as rectal, bladder, or penile branches, with an estimated incidence of < 5%.

Rare complications [16,21]:

- Erectile dysfunction, potentially resulting from embolization of the penile

artery; reported rates vary, with some studies noting around 1–2%.

- Ischemia or necrosis of surrounding tissues, typically associated with misdirected embolization.
- Severe complications (Clavien-Dindo grade III or higher) are very rare, estimated at 0.3%–0.4% in large series.

The current practice of PAE at our institution

At Tam Anh General Hospital in Ho Chi Minh City, most PAE procedures are performed with three-dimensional vascular mapping using cone-beam CT (CBCT) of both internal iliac arteries. This approach enables precise identification of the origins of the bilateral prostatic arteries and determination of the optimal C-arm angulation for selective catheterization. Using the 3D datasets, we employ the syngo Embolization Guidance software (Siemens) to delineate the course of the prostatic arteries, followed by roadmap-assisted navigation during the intervention based on the preconstructed vascular map. Incorporating CBCT and arterial pathway mapping significantly enhances technical success, with our bilateral PAE rate reaching approximately 98%, while also substantially reducing overall procedure time.

We have also standardized transradial access for pelvic embolization procedures such as PAE and uterine fibroid embolization. Radial access maintains procedural efficacy while providing greater postprocedural comfort, as patients are not required to remain immobilized for hemostasis, unlike with transfemoral access.

Regarding embolic materials, we primarily use microspheres. In cases of marked hypervascularity, we combine microspheres with PVA particles. In patients with prominent anastomoses where distal selective catheterization is not feasible, we deploy coils to occlude the anastomotic branch before proceeding with particulate embolization.

Illustrative Case

A 63-year-old male patient with a 6-month history of BPH presented with LUTS unresponsive to medical therapy. At admission, his IPSS was 29 and QoL score was 4. The patient had no history of hypertension, diabetes, or cardiovascular disease. Pre-procedure ultrasound revealed a total prostate volume of 47.45 mL and a PVR of 150 mL. The patient underwent bilateral prostatic artery embolization. At 6-month follow-up, lower urinary tract symptoms showed significant improvement.

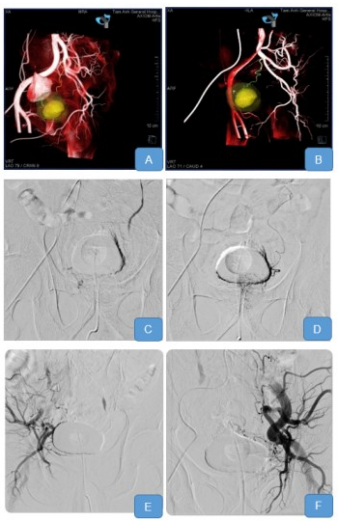

Figure 1. Illustration of a case of BPH treated with interventional procedure (Tam Anh General Hospital Ho Chi Minh City).

(A,B): 3D angiographic reconstructions of the right and left internal iliac arteries, respectively.

(C,D): Selective angiograms of the right and left prostatic arteries before embolization.

(E,F): Post-embolization angiograms of the right and left internal iliac arteries.

3. CONCLUSIONS

Endovascular intervention is a minimally invasive and highly effective treatment option with a low complication rate for patients with BPH. However, this technique requires highly skilled interventional radiologists with extensive experience in pelvic vascular anatomy to improve the success rate and minimize procedural risks and complications.

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