Prostate Artery Embolization

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Benign prostatic hyperplasia (BPH) involves the proliferation of the transition zone of the prostate,^{1,2} with resultant bladder outlet obstruction (BOO) and lower urinary tract symptoms (LUTS; frequency, urgency, weak stream, nocturia). The prevalence increases with age, affecting 50% of men in their 50s, with symptoms degrading quality of life (QoL).^{1,2} Prostatic arterial embolization (PAE) is safe and effective, demonstrating high rates of technical success, improved urinary flow rates, and QoL.^{3,4}

PAE can be a technically challenging and time-consuming procedure, especially given the general age of this patient population and concomitant medical comorbidities. Early enthusiasm in the procedure was tempered by variable clinical and technical success rates.^{5–9} These initial shortcomings were subsequently overcome by more standardization of techniques,^{10,11} and better understanding of patient selection and arterial anatomy.^{3,7,12–14}

Utilizing this refined anatomical and procedural expertise, the goal of this article is to provide a standardized approach to PAE to overcome technical challenges described in the literature.

Preprocedural Workup

All patients considered for PAE are evaluated by a multidisciplinary team consisting of interventional radiologists and urologists. Inclusion and exclusion criteria have been described extensively elsewhere.^{3,15,16} A diagnosis of BOO secondary to BPH by urologic or urodynamic evaluation is critical to exclude other causes of LUTS not amenable to BPH treatment.¹⁷ All patients complete baseline LUTS questionnaires (International Prostate Symptom Score [IPSS], QoL, and International Index of Erectile Function [(IIEF]) to determine baseline degree of LUTS and erectile function. Baseline PSA is obtained and further evaluation with prostate biopsy is performed if clinically warranted. Further evaluation with cross-sectional imaging (CT/MRI) may be obtained on a case-by-case basis depending on patient presentation and comorbidities.

Patients are started on ciprofloxacin prior to the procedure, which is continued for 5 days following the procedure.

We do not routinely place a Foley catheter during the procedure, utilizing a condom catheter instead. An indwelling catheter is reserved for patients who intermittently catheterize themselves at least four to six times a day or have an indwelling catheter.

Cone Beam CT

The prostatic arteries typically arise from the anterior division of the internal iliac artery; however, the specific origin branch may vary, and may be asymmetric between sides of the gland.^{12–14,18} This variability has led to various angiographic classifications^{13,14,19} based on the branching pattern. Thus, knowledge of the vascular anatomy is critical to technical success. However, due to wide variability in both branching pattern and vascular anastomoses, performing several angiographic runs to delineate anatomy can be both time consuming and difficult, requiring multiple oblique images. Additionally, collateral vessels supplying adjacent pelvic organs often anastomose with the prostatic artery (PA). If these vessels are not clearly identified, there is an increased risk of nontarget embolization, and subsequent adverse events.¹³ Collateral extraprostatic supply is common and therefore should be interrogated prior to embolization of the PA. Several authors have demonstrated that coil embolization of these vessels is both safe and technically successful in preventing nontarget embolization.^{20,21}

To prevent nontarget embolization, meticulous technique is necessary. In the case of PAE, this requires intraprocedural cone beam CT (CBCT) to confirm catheter placement and exclude nontarget embolization.^{18,22} In fact, CBCT provides essential information not seen during digital subtraction angiography (DSA) alone in 60.8% of cases.¹⁸ Additionally, a recent study demonstrated that CBCT identifies the PA with improved discrimination and less radiation dose than conventional preprocedural CTA.²³

For these reasons, we perform CBCT at the start of all procedures (–Table 1). Following arterial access, a 5-Fr pigtail catheter is advanced into the abdominal aorta to the level of the iliac bifurcation. CBCT is then performed to map the origins of

Table 1 Steps in the preprocedural evaluation and embolization procedure

Step	Description
Pelvic aortogram CBCT	<i>Settings:</i> Artis Q (Siemens Medical Solutions) with DynaCT (6 s acquisition) 5 mL/s for 12 s at 800 PSI
Right internal iliac artery catheterization and angiography	DSA 3 mL/s; 12 mL volume
Right PA catheterization, angiography $\pm$ CBCT	RAO/CC oblique determined from initial pelvic CBCT
Embolize right PA	Exclude nontarget embolization
Left internal iliac artery catheterization and angiography	<i>Standard anatomy:</i> Sos catheter selection using roadmap <i>Tortuous anatomy:</i> 7-Fr sheath support catheter technique DSA 3 mL/s; 12 mL volume
Left PA catheterization, angiography $\pm$ CBCT	LAO/CC oblique determined from initial pelvic CBCT
Embolize left PA	Exclude nontarget embolization

Abbreviations: CBCT, cone beam computed tomography; CC, craniocaudal; DSA, digital subtraction angiography; LAO, left anterior oblique; PA, prostatic artery; RAO, right anterior oblique.

both prostatic arteries. Pelvic CBCT is useful for several reasons. The origin of the PA can be identified bilaterally, as well as the optimal oblique for visualization during ipsilateral iliac angiography. We have found that while an ipsilateral anterior oblique projection with cranial angulation is needed to identify the PA origin, given the oftentimes concomitant vessels tortuosity, the typical 35-degree ipsilateral anterior oblique/10-degree cranial angulation is not sufficient, often due to the overlapping appearance of pelvic vessels.²³ Rather than perform several angiography runs to determine optimal positioning and separate overlapping vessels, a single pelvic CBCT allows us to visualize the number of prostatic arteries, their origins, and the angulation necessary to catheterize. This information also helps catheter and guidewire selection. Pelvic CBCT also improves prostate artery identification when used in conjunction with DSA.¹⁸ Additionally, CBCT can identify anastomoses with the vesical, rectal, and internal pudendal arteries such that coil embolization of these vessels can be performed prior to PA catheterization.²⁰ Finally, several of the previously identified pitfalls and artifacts of CBCT²⁴ can be mitigated with this overview of pelvic arterial anatomy, which may make it feasible to forgo subsequent interrogation of nontarget vessels. CBCT in conjunction with DSA delineates prostatic vascular supply, the flow characteristics of the prostatic vascular bed, which vessels require treatment, and the likelihood of nontarget embolization. By implementing this CBCT approach, we observed no cases of bladder, rectal, or penile ischemia.²²

Vessel Catheterization

Atherosclerosis commonly affects the iliac vasculature, and can lead to technical difficulties during PAE.²⁵ Given the concomitant comorbidities in this patient population, tortuous common or internal iliac arteries are often encountered. Additionally, the prostatic arteries often arise at acute angles, and exhibit atherosclerotic narrowing. Furthermore, the degree of atherosclerotic narrowing is significantly correlated with prostate size and BPH symptoms,^{26,27} such that the

most symptomatic patients may have the most challenging anatomy. These factors have been associated with increased technical difficulty when performing PAE.²⁸ Given these constraints, using conventional microcatheter/microwires in the anterior division may not provide sufficient directionality or support to enable vessel catheterization. In these cases, we have used a modified approach adapting techniques used for the treatment of peripheral arterial disease.

In the setting of severe iliac tortuosity or atherosclerosis, we typically proceed with treatment of the side ipsilateral to our initial arterial access. A 7-Fr vascular sheath is placed with a 035 Amplatz wire advanced into the abdominal aorta to straighten out any vascular tortuosity. In a side-by-side fashion through the sheath, the ipsilateral internal iliac artery is selected with the operator's reverse curve catheter of choice (Sos, Simmons 1 or 2). The buddy-wire in the abdominal aorta facilitates both catheter stability and maneuverability. If support from the base catheter is insufficient, we exchange for a 5-Fr Kumpe catheter. This is advanced into the anterior division as distal as possible. This provides increased proximal support and improved directionality for microcatheter PA selection (**Fig. 1**). Based on the initial pelvic CBCT, the image intensifier is adjusted ipsilateral oblique/cranial angulation needed for vessel catheterization (**Fig. 2**). A DSA is then performed from this angulation to visualize the PA origin. During DSA, opacification of the entire anterior division is necessary to guarantee visualization of both prostatic supply and any potential nontarget vessels, including any distal contribution from the internal pudendal or obturator arteries.²⁹ As discussed extensively in prior anatomic reports, once the PA origin is identified, catheterization is performed using the road-map technique, using a ≤ 2.4 Fr microcatheter (Merit, Salt Lake City, ID; Terumo, Somerset, NJ), with either a 0.014" or 0.016" shapeable hydrophilic microwires (Boston Scientific, Natick, MA; Stryker, Fremont, CA). Once the PA is catheterized, a suitable portion for embolization must be selected. Primarily, this must be beyond any potential nontarget vessels. Additionally, this must be proximal to any potential intraprostatic branch points to ensure thorough embolization of the gland. Care must be taken when addressing intraprostatic

Fig. 1 (a) Right internal iliac angiography through Sos catheter demonstrating acute, tortuous origin of the prostatic artery (arrows) from proximal internal pudendal artery. (b) Base catheter exchanged for Kumpe catheter which is advanced deep into the anterior division of internal iliac artery, proximal to prostatic artery origin (arrows). (c) Microcatheter advanced through base catheter into prostatic artery (arrows).

Fig. 2 (a) Pelvic CBCT volume rendered image demonstrating left anterior oblique angulation needed to visualize origin of left prostatic artery (white arrows) from anterior division of left internal iliac artery. (b) Left internal iliac artery DSA in same oblique determined by prior CBCT demonstrating origin of left prostatic artery (white arrows).

vascular branching, specifically the anterior/lateral prostatic artery and the posterior/lateral prostatic artery. The former is the principal focus of PAE, supplying the central gland tissue. The latter generally provides capsular supply, and may have anastomoses to extraprostatic tissues, such as the rectum or penis.

Special attention must be given to the case where the PA arises from a vesicoprostatic trunk from the proximal internal pudendal artery (►Fig. 3). The acute angulation of the PA origin here has been demonstrated to make catheterization difficult.²⁸ In these cases, we utilize a tight reverse curve catheter, either a TCBNK or modified Sos catheter (Cook, Bloomington, IN), advanced beyond the vessel origin. From

this location, the catheter is slowly retracted until it engages the vesico-prostatic trunk. From this location, a microcatheter and wire are advanced distally. Alternatively, this maneuver can be performed using an angled microcatheter or tip deflecting microcatheter forming a tight J-shape (►Fig. 4).

For the contralateral side, in routine cases without significant tortuosity, we advance a Sos catheter over the aortic bifurcation, using a guidewire advanced into the contralateral internal iliac artery. In cases of vessel tortuosity, we have modified catheterization techniques used for the treatment of peripheral arterial disease, termed the “reinforced sheath technique.” A 5-Fr Sos catheter (Cook) is advanced over the guidewire to just above the iliac bifurcation. If needed, an

Fig. 3 (a) Right internal iliac angiography demonstrating proximal stenosis of the anterior internal iliac artery as well as vesicoprostatic trunk (white arrow), and subsequent prostatic artery (black arrows). (b) TCBNK catheter used to engage vesicoprostatic trunk, with DSA demonstrating opacification of prostatic artery (white arrow). (c) Microcatheter advanced through base catheter into prostatic artery with DSA demonstrating prostatic perfusion (black arrows).

Fig. 4 (a) Right internal iliac angiography demonstrating atherosclerotic plaque in proximal anterior division of internal iliac artery and vesicoprostatic trunk (white arrow), and subsequent prostatic artery (black arrows). (b) Swift ninja microcatheter catheter used to engage vesicoprostatic trunk, with DSA demonstrating opacification of prostatic artery (black arrows). (c) Microcatheter advanced through base catheter into prostatic artery (black arrow) with DSA demonstrating prostatic perfusion.

arteriogram is performed to assess the iliac arteries in the contralateral oblique. Using the arteriogram as a guide with roadmap, a 0.035-in stiff angled guidewire (Terumo) is advanced through the SOS Omni catheter up and over the aortic bifurcation, and the catheter is advanced over the guidewire into the contralateral external iliac artery. The 5-Fr catheter and sheath are removed over the wire and exchanged for a 7-Fr, 45-cm sheath (Terumo), which is advanced over the aortic bifurcation into the contralateral external iliac artery. Next, the sheath dilator is removed, and as the sheath is pulled back over the wire, contrast is injected through the sheath to identify the internal iliac artery origin. Once identified, the internal iliac and subsequently the anterior division can be catheterized with a combination of a 5-Fr Kumpe catheter and guidewire in a side-by-side fashion. The stiff guidewire (safety wire) and reinforced sheath provides stable access during these maneuvers and aids in subsequent catheter maneuverability. From this point, the Kumpe catheter can be directed toward the PA

origin in the ipsilateral oblique/cranial angulation determined by the initial CBCT (→Fig. 5). DSA is performed to identify the PA origin, as discussed earlier.

Embolization

Once catheterized, angiography is performed in the ipsilateral oblique and frontal projections to demonstrate adequate filling of the prostatic vascular bed, as well as potential nontarget vessels. These may be seen in 10 to 20% of patients.^{30,31} However, a distinction must be made between small and large extraprostatic shunts. The former is frequently not visible on DSA unless a high-powered injection is employed. In the context of slow-flow embolization utilized in PAE, nontarget delivery of particles to these vessels is not encountered due to preferential flow to the prostate.^{20,30} In the case of larger shunts that are visible on DSA or low-pressure injection, these may either be avoided through advancement of the microcatheter distal to their takeoff or with coil embolization. The

Fig. 5 (a) Coronal MIP of aortic bifurcation demonstrating high aortoiliac bifurcation and severe tortuosity. (b) AP view of the pelvis with Sos catheter at the level of the aortic bifurcation, with guidewire advanced into contralateral external iliac artery. (c) 7-Fr sheath advanced over the bifurcation into contralateral external iliac artery over sheath dilator. (d) Sheath withdrawn over the guidewire with injection of contrast demonstrating origin of internal iliac artery. (e) Kumpe catheter and second guidewire advanced into internal iliac artery, with original guidewire used as buddy-wire for support. (f) Left internal iliac angiography through Kumpe catheter demonstrating origin of prostatic artery. (g) Microcatheter advanced into prostatic artery demonstrating prostatic perfusion.

vessels at risk of nontarget embolization have been described extensively elsewhere,³⁰ and include superior vesicle, rectal, and pudendal branches. These anastomoses can be safely coil embolized without compromising therapeutic efficacy or increasing adverse events.²⁰ The authors favor the use of small 3-mm pushable coils in these cases (►Fig. 6). Early in one's PAE experience, it may be prudent to coil embolize all potential nontarget vessels within the treatment zone, to avoid off-target microsphere deposition. With increased technical expertise, coil embolization of these vessels may not be necessary as long as injection pressure during DSA/embolization does not exceed inflow from these extraprostatic vessels, such that this inflow can be considered protective.

We perform embolization with 300 to 500 μ m particles, with several studies demonstrating equivalent efficacy and decreased adverse events compared with 100 to 300 μ m particles and nonspherical PVA.^{10,11} Unlike other vascular beds, embolization during PAE is a pressure-dependent, rather than flow-directed, phenomenon, due to small arterial caliber. As such, increased injection pressure can increase the likelihood of reflux and nontarget embolization. We therefore perform a slow controlled embolization using high dilution of particles to contrast.^{7,32,33} With the use of the previously described techniques with regard to artery identification, intraprocedural CBCT, and coil embolization, we have observed no cases of bladder, rectal, or penile ischemia, and a favorable adverse event profile.¹⁵

Steps in the preprocedural evaluation and embolization procedure for prostate embolization are outlined in ►Table 1.

Post-procedural Management

Following recovery, patients are asked to void. If their post-void residual volume (PVR) is less than 200 mL or in line with

their screening PVR, they are subsequently discharged. Otherwise the voiding trial and PVR are repeated. Patients with chronic indwelling Foley catheters are instructed to return in 2 to 3 weeks for a voiding trial. Several series have reported successful voiding trials in the majority of these patients 10 to 20 days post-PAE, which has been concordant with our own experience.^{3,6,15,34}

Patients are discharged with nonsteroidal anti-inflammatories, a proton pump inhibitor, and antibiotics for 5 days for potential post-PAE syndrome. This typically consists of urinary frequency and dysuria lasting up to 5 days.²² Patients are subsequently seen 1, 3, 6, and 12 months following PAE for clinical assessment. Imaging assessment with postprocedural MRI is obtained at 6 months if comparative preprocedural imaging is available. From our own series, we have observed a 11- to 12-point reduction in IPSS and a 2- to 3-point improvement in QoL up to 1 year following PAE, similar to other series.¹⁵ We observed no severe adverse events, nontarget embolization, or adverse effects on erectile function or sexual health.¹⁵ On follow-up MR imaging, we saw a 26% decrease in central gland volume, including a 25% reduction in intravesical prostatic protrusion or median lobe size, again in line with other imaging series.³⁵⁻³⁷

PAE is both a safe and effective treatment for BPH; however, meticulous technique is required for both technical and clinical success. Anatomic variability and tortuous atherosclerotic vasculature can pose significant technical challenges. Additionally, one must be wary of extraprostatic anastomoses that can increase the risk of nontarget embolization. A methodical approach to angiography, incorporating techniques utilized in the treatment of peripheral vascular disease, can facilitate optimal outcomes.

Fig. 6 (a) Right internal iliac angiography demonstrating origin of the prostatic artery (*black arrows*), as well as obturator artery (*white arrows*). Prostatic perfusion demonstrating potential intraprostatic anastomosis between prostatic and obturator arteries (*arrow heads*). (b) Right prostatic artery (*black arrows*) DSA demonstrating arterial anastomosis (*arrow heads*) extending beyond prostatic borders. (c) Microcatheter advanced through anastomosis with DSA demonstrating reflux into obturator artery (*white arrows*). (d) Microcatheter retracted into main prostatic artery following coil embolization of the anastomosis (*asterisk*). Prostatic perfusion seen without opacification of obturator anastomosis (*arrows*).

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Conflict of Interest

None.

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