Seminars in ULTRASOUND CT and MRI

Prostate Artery Embolization for Benign Prostate Hyperplasia Review: Patient Selection, Outcomes, and Technique

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Prostate artery embolization (PAE) is a minimally invasive technique in managing men with lower urinary tract symptoms (LUTS) secondary to benign prostatic hyperplasia (BPH). BPH is one of the commonest causes of LUTS in men, associated with high morbidity and economic burden. Patients suffering from LUTS secondary to BPH, severe enough to warrant intervention traditionally underwent transurethral resection of the prostate or open prostatectomy. PAE is an emerging alterative technique with promising data. In this paper we review important elements to running a safe PAE practice including careful patient selection, exclusion criteria, complications, and efficacy of PAE compared to other techniques. This paper also reviews the basic anatomy and techniques relevant to PAE, including common anatomical variants.

Semin Ultrasound CT MRI 41:357-365 © 2020 Published by Elsevier Inc.

Background

Benign prostate hyperplasia (BPH) is a common condition that affects men of advancing age, dramatically increasing after the age of 50.[1,2] Under hormonal influence stromal and epithelial cells in the transition zone of the prostate proliferate causing the prostate to increase in size.[3] Although the exact pathogenesis is not fully understood, it is postulated that hyperplasia of the periurethral prostate, alongside other complex mechanisms, lead to compression of the prostatic urethra, bladder outlet obstruction, and lower urinary tract symptoms (LUTS).[3] LUTS can be defined as a mixture of storage, voiding and postmicturition symptoms.[4] Alongside the significant morbidity and reduction in quality of life (QOL) associated with LUTS secondary to BPH, is a substantial economic burden which has been estimated to be an annual cost of approximately $4 billion dollars in the United States.[5]

First line management of LUTS secondary to BPH is usually lifestyle modification and medications, most commonly alpha-1-blockers with or without 5-alpha-reductase inhibitors.[6] Medications may have a modest efficacy in controlling LUTS secondary to BPH.[4] Invasive interventions are considered in patients whose symptoms are not controlled or those who experience intolerable side effects,[6] Surgical therapies such as transurethral resection of the prostate (TURP) and open prostatectomy (OP) are the gold standard interventions for LUTS secondary to BPH.[7] These procedures are effective but are associated with significant complications.[8] The risk profile of these traditional procedures led to the development of a range of minimally invasive surgical therapies.[9] The reduced complication rates associated with minimally invasive surgical therapies however come at the price of reduced efficacy compared to TURP and OP. There are also higher rates of clinical failure requiring follow up treatment.[7]

Prostate artery embolization (PAE) offers a minimally invasive, safe and effective alternative intervention, which in selected patients, has shown to be both effective and safe.[10] It is hypothesized that PAE improves LUTS by causing ischemic shrinkage of the prostate[11] and softening its consistency after embolization.[12] PAE was first performed in the 1970s to

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https://doi.org/10.1053/j.sult.2020.04.001
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manage hemorrhage following prostatic interventions.[13] However, the earliest case report describing its treatment of LUTS in BPH was published in the beginning of the new millennium.[14] Gradually several more case series followed. In 2014, the society of interventional radiology concluded that PAE offered a safe treatment option for treating LUTS in BPH.[15] The United Kingdom National Institute for Health Care Excellence (NICE) in 2018 concluded that "the current evidence on the safety and efficacy of PAE for benign prostatic hyperplasia is adequate to support the use of this procedure" (NICE, 2018).

We aim to provide an objective, updated review of PAE in the management of LUTS. We will elaborate on important clinical and technical considerations essential for successful and safe PAE practice.

Patient Selection and Investigation

A successful outcome for PAE requires careful patient selection by clinical assessment and investigations. There are multiple etiologies to LUTS and only 25%-50% of men with BPH have LUTS (NICE, 2015). To ensure patient suitability and to ensure that the LUTS symptoms are secondary to BPH, multiple parameters and investigations are considered in the patient selection process.[16] NICE guidelines recommend this is done by a Urologist and an Interventional Radiologist (NICE, 2018). Table 1 summarizes the inclusion and exclusion criteria for PAE.

An important part of the initial selection process is establishing whether the LUTS is sufficiently severe to warrant PAE.[16] To quantify the severity of symptoms, patients are given questionnaires to score their symptoms. The international prostate symptom score (IPSS) and QOL are the most commonly used questionnaires and are invaluable tools in evaluating LUTS symptoms pre and post intervention.[17] For IPSS, the score ranges from 0 (asymptomatic) to 35 (most severe symptoms).[17] Patients scoring an IPSS of ≥ 8 have symptoms that are severe enough to warrant further investigation.[16] Patients with BPH suffering with acute urinary retention refractory to medical treatment should be considered for PAE.[10]

Table 1 Inclusion and Exclusion Criteria of PAE

Inclusion Criteria	Exclusion Criteria
Moderate to severe LUTS attributed to BPH	Severe uncorrectable coagulopathy
Poor response/intolerance to medication	Severe allergy to iodinated contrast
Unfitness for surgery or anesthesia due to comorbidities or coagulopathy	Severe renal impairment*
Hematuria of prostatic origin	Severe atherosclerosis*
Desiring preserved post-operative sexual functions (erection & ejaculation)	Active UTI*
Refusal of transurethral or surgical procedures	Prostate cancer*

*relative contraindications.

If a patient's symptoms are severe enough to warrant PAE, it is then important to establish if the cause is from BPH and the Urologist plays an important role in this process. Uroflowmetry studies and postvoid residual volume are essential in the workup for PAE in noncatheter dependent patients and help determine if the cause of symptoms are secondary to BPH.[18] One important parameter is maximum flow rate (Qmax).[18] If the Qmax is higher than >15 mL/s then the cause of LUTS is less likely to be secondary to BPH and the patient should be further investigated.[18]

Patients should also be screened for prostate cancer as a cause of their LUTS.[16] Although prostate cancer is not an absolute contraindication and PAE can help symptoms,[19,20] it is important to establish if the patient has prostate cancer prior to procedure and discuss in a multidisciplinary team meeting. If the etiology of LUTS is unclear or equivocal, cystoscopy and invasive urodynamic studies should be considered to exclude other causes.[16,18] A common manifestation of bladder outlet obstruction is the development of bladder diverticula. Early studies did not recommend PAE, as diverticula may be contributing to the LUTS. A recent study concluded that patients with bladder diverticula can benefit from PAE but those with large bladder diverticula are less likely to benefit, as the diverticula may be the cause of the symptoms.[21]

If LUTS symptoms are severe enough to warrant PAE and likely secondary to BPH, investigations are then performed to assess vascular anatomy. Computed tomography angiogram or magnetic resonance angiogram are useful investigations for procedure planning.[22,23] Patients with advanced atherosclerotic disease can pose technical challenges, and extreme cases of tortuosity and atherosclerosis may not be suitable, depending on the experience of the operator. Review of the arterial anatomy is an important part of procedure planning, can shorten the procedure and reduce radiation exposure.[24] Cross sectional imaging and US can also be useful in assessing prostatic size. Patients with large prostates tend to respond well to PAE,[25] whilst those with prostates smaller than 40g are unlikely to benefit from PAE and are likely to have an alternate cause for LUTS.[16]

There are few absolute contraindications to performing PAE. As with other vascular interventional radiology procedures; known allergy to iodinated contrast, uncorrectable coagulopathy, and severe renal impairment are the most common contraindications. Renal dysfunction secondary to BPH is not uncommon and is considered a relative contraindication to PAE due to increased risk of contrast induced acute kidney injury, especially when the eGFR is less than 30 mL/min/1.73m^2. Perioperative intravenous hydration may reduce this risk and patients with renal impairment would be evaluated on a case by case basis (The Royal Australian and New Zealand College of Radiologists. Iodinated Contrast Media Guideline. Sydney: RANZCR; 2018).There are a limited number of case reports in which carbon dioxide has been used as an alternative contrast agent, however further research is required.[26,27]

PAE Outcomes: Efficacy and Safety

Efficacy

Multiple studies have demonstrated PAE to be effective in improving BPH induced LUTS and urinary retention.[10] Subjective and objective parameters measured in the selection process are again measured post procedure for comparison. The most common subjective outcomes measured are IPSS, QOL, & International Index of Erectile Function (IIEF) and the most common objective outcomes measured are the Qmax, prostate volume (PV) and postvoid residual urine volume. Studies in the literature have consistently shown a statistically significant improvement in both subjective and objective parameters post PAE. Multiple meta-analysis studies have shown a significant reduction in IPSS and improvement of other parameters.[28-31] Table 2 shows data from a meta-analysis in which the average reduction in IPSS at 1 year post-PAE exceeded 20 points.[28]

A randomized control trial (RCT) of 80 patients, comparing PAE to a sham procedure, has shown an average reduction of 17.1 IPSS points at 6 months post-PAE compared to 5.03 IPSS points in the sham arm. Table 3 shows the other parameters that were compared between PAE and the sham arm. All measured objective and subjective parameters had shown a statistically significant improvement except IIEF which remained unchanged.[32]

An RCT of 114 patients, comparing PAE to TURP found a statistically significant improvement of objective and subjective outcomes after both TURP and PAE procedures and were followed up for 2 years. TURP performed better only within the early postoperative period (first 3 months of follow up). Haemoglobin drop, postoperative urinary catheterization and hospital stay were all more significant with TURP (all P values < 0.001).[33] Another meta-analysis study comparing the efficacy of PAE to TURP, found both modalities were similar in reducing IPSS with insignificant difference between them (mean difference: 1.56, 95%CI: −0.67 to 3.78, $P = 0.17$). However, in the TURP arm, QOL, and Qmax were found to be better by 0.53 points (95%CI: −0.88 to −0.18, $P = 0.003$) and 4.66 mL/s (95%CI: 2.54-6.79, $P < 0.00001$), respectively.[34]

A large case series of 630 patients had a long follow up time of 6.5 years. The authors measured clinical success, which they defined as an IPSS decrease $\geq$ 15 points and a decrease of $>$ 25% from baseline, improved QOL to $\leq$ 3 points or a decrease of at least 1 point from baseline, without the need of any medical or other therapy. In this study clinical success was achieved in 85.1% at 1 year, and beyond 3 years the accumulated data had shown a persistent clinical success in 76.3% of patients (95%CI: 68.6-82.4). Table 4 summarizes the long-term mean changes (3-6.5 years) of outcomes from baseline.[35]

Another indication for performing PAE is to obtain catheter independence in patients suffering from urinary retention. A study of 30 patients with preoperative catheter dependence associated with high comorbidity scores and average PV 167.3 cc (range: 55-557 cc), achieved urinary catheter independence in 86.7% after 18 days post-PAE. The average prostate volume fell to 115.9 cc at 3 months postprocedure ($P < 0.001$). Almost all complications in this study were mild and self-limiting.[36] Another large case series did not exclude 112 patients in urinary retention, who responded well to PAE with catheter independence achieved in 106 cases (94.6%).[37] Table 5 summarizes data for patients suffering from urinary retention who underwent PAE.[36]

Table 2 Summary of the Average Changes From Baseline at 1- and 12-Months Post-PAE, From One Meta-Analysis Study[28]

Outcome Parameter	Mean Change at 1 Month (95% CI, *P* Value)	Mean Change at 1 Year (95% CI, *P* Value)
IPSS	−12.93 (−15.44 to −10.42, <0.001)	−20.39 (−28.79 to −11.98, <0.001)
QOL	−2.17 (−2.52 to −1.81, <0.001)	−2.49 (−2.65 to −2.33, <0.001)
Qmax (mL/s)	4.66 (2.49-6.83, <0.001)	5.39 (4.17-6.6, <0.001)
PVR (mL)	−62.03 (−87.77 to −36.3, 0.004)	−85.54 (−101.43 to −69.66, <0.001)
PV (cc)	−14.51 (−16.66 to −12.36, <0.001)	−31.31 (−44.89 to −17.73, <0.001)
IIEF	0.07 (−1.07 to 1.2, 0.292)	0.64 (−1.24 to 2.52, 1)

Table 3 Summary of Results From a RCT Comparing PAE to Sham Procedure[32]

Outcome Parameter	Sham procedure		PAE		Difference PAE − Sham (95%CI, *P* Value)
	Baseline Values (Median)	Mean Changes After Sham	Baseline Values (Median)	Mean Changes After PAE	
IPSS	27.5	−5.03	25.5	−17.1	−13.2 (−16.2 to −10.2, <0.0001)
QOL	4.5	−1.03	4	−3	−1.99 (−2.51 to −1.46, <0.0001)
Qmax (mL/s)	7.3	2.8	7.9	6.82	4.22 (0.86-7.58, 0.005)
PVR (mL)	106	8.63	119	−59.9	−60.6 (−116.7 to −4.6, 0.03)
PV (cc)	66.5	−0.06	68.5	−17.6	−16.8 (−29.2 to −4.52, 0.002)
IIEF	46	5.95	52.5	9.53	7.28 (−2.32 to 16.9, 0.29)

Table 4 Long-Term Outcomes After PAE[35]

Outcome Parameter	Baseline Values (Mean)	Long-Term Mean Changes > 3 Years (95%CI)
IPSS	23.1 (2-35)	−16.94 (−19.89 to −14)
QOL	4.23 (0-6)	−1.74 (−2.21 to −1.26)
Qmax (mL/s)	11.2 (0-713)	7.98 (3.24-6.73)
PVR (mL)	109.4 (0-537)	−52.16 (−87.34 to −16.98)
PV (cc)	81.4 (18-383)	−16.85 (−25.68 to −8.02)
PV (%)	Not applicable	−15.71 (−24.08 to −7.33)
IIEF	18.5 (0-34)	0.07 (−1.07 to 1.2)

One of the distinguishing advantages of PAE is its potential as a minimally invasive procedure for large prostates.[35,36,38-41] TURP is generally not recommended for patients with prostates greater than 80-100 mL and OP is usually the treatment of choice; this is a major procedure.[7] PAE has been found to be effective in patients independent of prostate size.[42] Studies investigating patients with large prostates (even exceeding 550 mL[36]) found post-PAE, PV reduction >44%[38] and average drop of IPSS >85%.[39] Tables 6 and 7 summarize data from 2 different single center prospective studies on the efficacy of PAE in patients suffering with BPH and large PVs (> 80-90 g).

In some patients, preservation of sexual function is the major driving factor in treatment selection. Sexual function is important for some patients and traditional procedures are generally poor at preserving this. Several studies have shown stable IIEF post-PAE,[28] with some large studies even reporting slight, but statistically significant improvement in erectile function post-PAE (3.4 IIEF points, 95%CI: 1.1-5.8, $P < 0.005$).[29,35,43] No study to our knowledge has shown a reduction in IIEF score. One study found retrograde ejaculation after PAE in about 24.1% of cases, almost half that seen post TURP (47.5%).[43] However, this finding is unusual and was not encountered in other large PAE meta-analysis[28] and series.[35] The authors attributed this overestimation to preoperative medications rather than true post-PAE complication.[43] However, reduced ejaculate volume has been described after PAE (<1%).[29] Compared to TURP[44] and OP,[45] PAE is superior at preserving sexual function.[46] A comparative study of 160 patients demonstrated that that there was an improvement of about 5 IIEF points in PAE compared to OP (P value < 0.01).[45] Preserved fertility and successful conception have even been reported post-PAE.[35] Consequently, PAE should always be considered as an alternative for patients who want to preserve sexual functions.

Technical success of the procedure is another important parameter in determining overall efficacy. PAE can be a

Table 5 Summary of Changes After PAE for Urinary Retention[36]

Outcome Parameter	Baseline (Mean)	3 Months Post-PAE (*P* Value)	12 Months Post-PAE (*P* Value)
IPSS	Not applicable	7.2	6.3
QOL	5.3	1.2 (<0.001)	0.6 (<0.001)
Qmax (mL/s)	Not applicable	9.3	10.3
PVR (mL)	Not applicable	57.8	27.9
PV (cc)	167.3	115.9 (<0.001)	94.1 (0.053)
IIEF	Not applicable	19.5	20.2

Table 6 Summary of Changes After PAE for Large Prostates (>90 g)[39]

Outcome Parameter	Baseline (Mean)	3 Months Post-PAE (*P* Value)	12 Months Post-PAE (*P* Value)
IPSS	23.98	12.2 (0.03)	10.4 (0.02)
QOL	5.1	2.8 (0.01)	2.2 (0.02)
Qmax (mL/s)	7.28	14.95 (0.03)	16.89 (0.03)
PVR (mL)	75.25	19.75 (0.03)	18.38 (0.04)
PV (cc)	129.31	87.3 (0.04)	71.2 (0.04)
IIEF	14.45	15.53 (0.6)	15.13 (0.54)

Table 7 Summary of Changes After PAE for Large Prostates (>80 g)[38]

Outcome Parameter	Baseline (Mean)	3 Months Post-PAE	Percent Change (*P* Value)
IPSS	18.3	2.7	−85.2% (<0.0001)
QOL	4.8	0.9	−81.2% (<0.0001)
Qmax (mL/s)	7.1	15.2	114.1% (<0.0001)
PV (cc)	135.1	91.9	−32% (<0.0001)

challenging procedure to perform in patients with severe atherosclerosis and tortuous vascular anatomy. The standard is to embolize the prostatic arteries (PAs) bilaterally; however unilateral PAE has been encountered due to the above-mentioned reasons, usually in <20% of cases.[28,29] Unilateral PAE can still result in statistically significant improvement with a postoperative IPSS reduction of 32.9% compared to 54.4% in bilateral PAE (*P* value = 0.026).[25] However, the unilateral approach is associated with poorer long-term outcomes compared to bilateral PAE (47% vs 24% respectively).[47] Therefore, PAE may still have a role in patients who have technically challenging vascular anatomy and unsuitable for other procedures.

Safety

PAE is a relatively safe procedure with a relatively low risk profile. It is usually performed as a day case under local anesthetic and has a short recovery time.[10] Complications may arise from nontarget embolization (NTE), infection, vascular access or intravenous contrast use.[48]

Post-embolization syndrome should be anticipated after PAE and can therefore be considered as a side effect rather than a complication. This collectively describes symptoms of urinary urgency, frequency, dysuria, pressure in the pelvis, and/or pain in the pelvis. This usually lasts up to one week and is managed conservatively using analgesia and hydration.[46,48]

Minor complications can occur including urinary retention requiring catheterization (<5%), urinary tract infection requiring antibiotics (<10%) and minor local arterial dissection (2%). Patients may also encounter transient post-procedure hematuria, hematospermia, and abnormal ejaculation. Table 8 summarizes minor complications encountered post-PAE from a large meta-analysis of 1253 patients.[29]

Serious complications secondary to PAE are extremely rare and are usually attributable to NTE. This can occur as a result of embolizing misidentified arteries, significant reflux of embolic material or overlooked anastomosis. Nearby potentially affected organs include rectum, penis, seminal vesicles, bladder, pelvic bones and muscles. Fortunately, these complications are either rare or self-limiting in almost all situations.

In a large meta-analysis of 1253 cases of PAE, only 3 major complications were reported (0.24%). The 3 complications were bladder wall ischemia requiring partial surgical resection, UTI requiring intravenous antibiotics and persistent perineal pain lasting for 3 months.[29] Another case of extensive bladder wall ischemia has been reported, yet it responded to conservative management (urinary catheterization and antibiotics) with no need for endoscopic intervention; in this case report, 100 μm embolic particles were used, which are no longer recommended due to high risk of associated complications.[49] Another case of bladder ischemia requiring surgical intervention (uneventful partial bladder wall resection) has been reported but occurred in the early practice of PAE (2011) with the use of particles measuring 200 μm, which is no longer the recommended particle size.[50]

When compared to TURP, a RCT had shown that TURP was associated with double the complication rates (n = 70 vs n = 35, *P* value = 0.003); for example postoperative hemoglobin drop for TURP and PAE were 1.38 vs 0.43 g/dL (*P* value = 0.001), respectively.[51] A meta-analysis found complications were only marginally statistically insignificant in favor of PAE (odds ratio: 1.54, 95%CI: 1-2.38, *P* = 0.05).[34] This study however did not stratify the severity of complications, which overestimated the risk from PAE due to the relatively high incidence of mild adverse events, such as Post-embolization syndrome which many consider not to be a complication. A study comparing PAE to OP found statistically significant difference in safety; with severe complications exclusively occurring with OP as well as a higher frequency of mild and/or moderate complications (*P* value < 0.05).[45] Table 9 compares incidence and severity of complications post OP vs PAE.

PAE avoids certain risks seen with TURP and OP such as urinary incontinence, urethral strictures, bladder neck injury, severe hematuria and transurethral resection syndrome - a rare potentially fatal condition resulting in osmotic demyelination syndrome.[8,33,45,46] Overall, fewer patients were admitted to the hospital after PAE, and their average hospital stay was shorter compared with TURP and prostatectomy.[45,51]

Table 8 Summary of Minor Complications After PAE[29]

Minor Complications	Frequency (%)
Dysuria	212 (16.92)
Frequency	145 (11.57)
Obstipation	76 (6.07)
hematospermia	69 (5.51)
Hematuria	69 (5.51)
Urinary retention	57 (4.55)
Transient rectal bleeding	57 (4.55)
post-embolization syndrome	47 (3.75)
Urinary tract infection treated with oral antibiotics	33 (2.63)
Groin hematoma	19 (1.52)
Reduction in ejaculate volume	9 (0.72)
Balanitis	4 (0.32)
Rectorrhagia	3 (0.24)
Diarrhea	2 (0.16)
Hyperthermia	1 (0.08)
Severe pelvic pain	1 (0.08)
Transient pubic bone ischemia	1 (0.08)

Table 9 Comparison of Complications After OP Vs PAE[45]

Complication	Open Prostatectomy	PAE
Grade 1	11 (13.75%)	6 (7.5%)
Grade 2	10 (12.5%)	1 (1.25%)
Grade 3a:	3 (3.75%)	0
Urethral/bladder neck stricture (requiring endoscopy)		
Urgency/incontinence (requiring anticholinergics)		
Total	25 (31.25%)	7 (8.75%)

Risks from radiation exposure during PAE are assumed to be no different from other pelvic angiographic procedures; advanced age and male sex are generally associated with reduced risk.[52] Radiation associated injury is very rare with only 1 case of radiodermatitis post-PAE reported in the literature. The patient developed focal area dermatitis in the lower back approximately 2 weeks after the procedure and improved with topical treatment.[53]

Anatomy & Technique

Anatomy

A key to the successful performance of PAE relies on the understanding of the anatomy, especially the prostatic arterial anatomy. Prostate artery (PA) usually arises as a small branch from the anterior division of the internal iliac artery (IIA-AD) but has a variable origin. The prostate is most commonly supplied by 2 arteries, 1 on each side although 3 or 4 arteries can be found in up to 12% of cases.[25] Several IIA branching pattern classifications have been put forward to help better understand variant anatomy. The classification proposed by Carnevale provides a simple yet practical depiction of this, which can be applied in PAE practice.[54] Carnevale type I to IV represent PA arising from superior vesical artery, directly from IIA-AD, obturator artery or internal pudendal artery, respectively; Carnevale type V pattern is the least common, arising elsewhere. Prevalence rates of type I to V are 28.7%, 14.7%, 18.9%, 31.1%, and 5.6%, respectively.[54] Figures 1 and 2 demonstrate the 2 most common variants (type I and IV) which are collectively found in about 60% of patients.

In about half of cases, the configuration of the PA is symmetrical.[24] Identification and adequate embolization of both central and capsular branches of the PA is extremely important as failure to do so may lead to revascularization of the prostate which can contribute to clinical failure.[55] Figure 3 shows a typical appearance of PA branching into central and capsular branches.

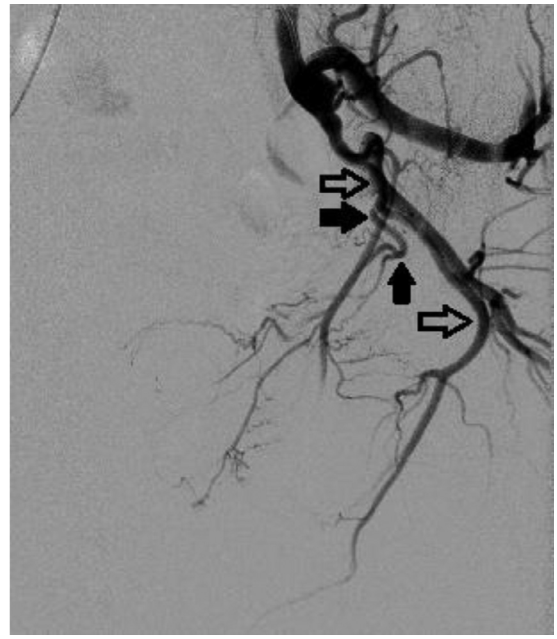

Figure 2. DSA LAO of left internal iliac artery showing left prostatic artery (arrows) arising from internal pudendal artery (hollow arrows).

PA anastomosis with nearby non-target organs is common and identification of such anastomoses is essential to avoid schemic complications due to NTE. Most anastomoses are found near the prostatic apex, communicating with nearby penile, rectal and vesical arterial beds; in 25.2%, 24%, and 20.6% of cases respectively.[25] Anastomoses between both hemiprostates may also be seen in about 3% of cases[56]; This can allow entire embolization from 1 side, especially useful in cases where the contralateral artery can not be catheterized.[57]

A)

B)

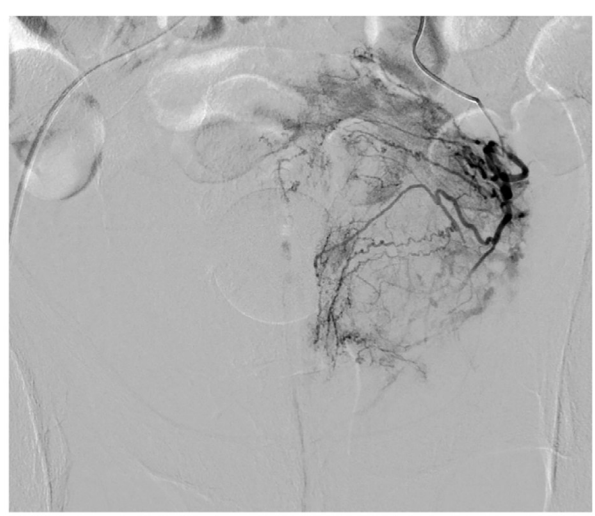

Figure 1 (A) DSA LAO of left common iliac, branching into internal and external iliac artery (star). Internal iliac artery branches into anterior division (arrow head) and posterior division (hollow arrow head). PA (arrow) arises from a short trunk with superior vesical artery (hollow arrow); (B) DSA LAO of the same patient showing microcatheter inside left PA with left hemiprostate blush (> 500 cc).

Figure 3 Frontal DSA showing microcatheter inside PA with left hemiprostate blush. Note the branching of PA into central (arrow) and capsular branches (hollow arrow).

Technique

Antibiotic prophylaxis is recommended prior to PAE and should be given according to local departmental guidelines. A urinary catheter may or may not be inserted prior to the procedure to aid with localization of the prostate. Practices will vary based on experience and operator preference. Arterial access is gained via a transfemoral or transradial approach. Occasionally bilateral femoral access might be needed to overcome tortuous iliac anatomy (4% of patients).[35] The transradial approach may be limited by the patient's height, but results in easier hemostasis and shorter recovery times compared with femoral access.[58,59]

The (IIA-AD) is catheterized in turn and an angiographic run is acquired in the ipsilateral anterior oblique (35°) and caudocranial (10°) projection to separate the origins of IIA-AD branches and identify the PAs, which are then selectively cannulated using a microcatheter. Spasm in these small vessels can often occur but can be overcome using intra-arterial vasodilator (eg, 100-200 μg nitroglycerin) throughout the procedure if this can be tolerated by the patient.

Once catheterized, prior to embolization, a cone beam CT is advised to confirm position in the PA and to unmask any anastomoses. Microspheres are preferred to nonspherical PVA particles as embolic agents as they have demonstrated greater statistically significant prostatic volume reduction.[60] About 300-500 μm particles are recommended as they result in equivalent improvement but statistically significant fewer adverse events compared with smaller particles.[61,62]

Prior to embolization, protective occlusion using coils or gelfoam is useful in situations when anastomotic channels are relatively large, accessible and can be safely occluded.[63,64] Figure 4 depicts a situation when coiling can be useful. Smaller distal, microanastomosis that are nonaccessible are more challenging to deal with and novel techniques have been proposed to address these challenges. Balloon-assisted PAE is being investigated by altering the local hemodynamics and redirecting flow from a nontarget territory into the prostate through micro-anastomosis, avoiding NTE.[65] A similar reversal of flow can be achieved by slow injection of intra-arterial verapamil into the PA (3-5 mg, concentration of 0.5 mg/mL, effect lasts about 5 minutes) prior to embolization; it is postulated that the vasodilatory effect on the prostatic bed will redirect flow and enable safe embolization.[66]

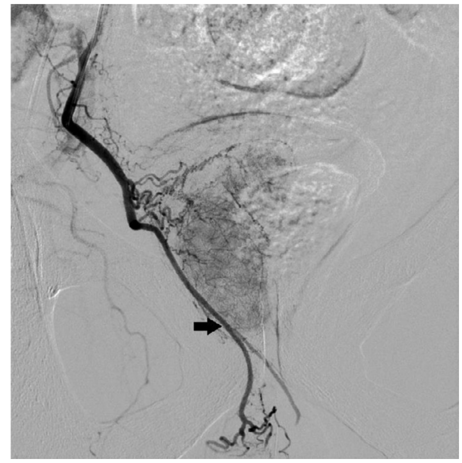

Figure 4 Frontal DSA with microcatheter inside left PA; however, there is large accessory pudendal supply prohibiting embolization in such situation. The ideal solution is coiling of accessory pudendal artery at the arrow position before injecting embolization particles.

Once embolized, where possible the microcatheter should be advanced as distally as possible in the PA and embolized further. This is known as the "PErFecTED" technique (Proximal Embolisation First Then Embolise Distal) and has been shown to be associated with better patient outcomes.[67] This may also facilitate embolization of the contralateral PA, which is particularly useful in cases where the prostatic arterial supply is only accessible from 1 side.[56] Figure 5 demonstrates the angiographic endpoint of successful embolization.

In some cases (<20%) where bilateral PAE cannot be performed, unilateral PAE has been shown to result in statistically significant objective and subjective improvement[28,29]; with a postoperative IPSS reduction of 32.9% compared to 54.4% in bilateral PAE (P value = 0.026).[25] However, unfortunately it is associated with poorer long-term outcomes compared to bilateral PAE (47% vs 24% respectively).[47] PAE may still have a role in patients who have technically challenging vascular anatomy and unsuitable for other procedures.

Conclusion

PAE is a local anesthetic day case procedure, which offers a safe and effective treatment option in the management of moderate to severe LUTS secondary to BPH. Careful patient selection, planning, refined technique and close collaboration with the Urologists is key to achieving desired patient outcomes. With increasing experience, advancing techniques and developing equipment, PAE looks like a more promising

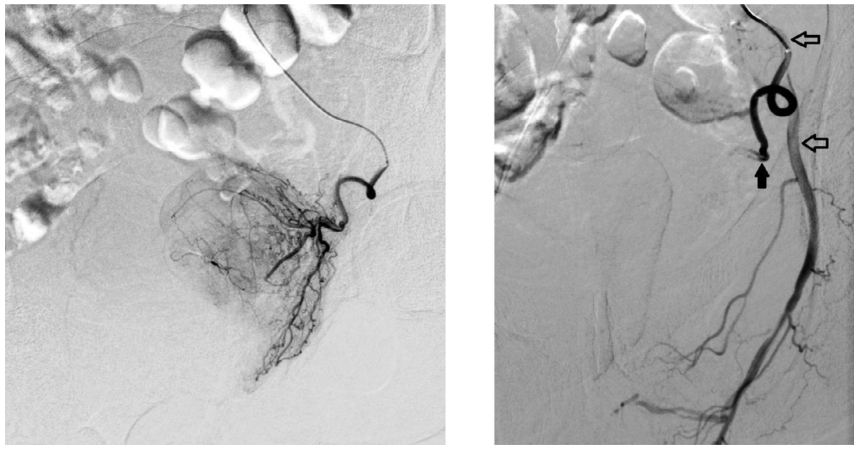

Figure 5 (A) DSA LAO showing microcatheter inside left prostatic artery with left hemiprostate blush. (B) Frontal control angiogram of the same patient after embolization of left prostatic artery; showing contrast stasis (arrow) and reflux (hollow arrows), denoting adequate embolization.

option to a wider patient cohort, who may have previously not been considered for this treatment. The transradial approach has allowed us to consider PAE for patients with tortuous anatomy and uncorrectable coagulopathy. Further studies are required on the evolving role in managing LUTS and hematuria in prostate cancer. Increasing familiarity and experience with CO_2 angiography may allow consideration of patients with severe renal impairment, whilst emerging novel techniques such as balloon assisted embolization, may help facilitate safer embolization in patients with more complex microanastomoses. Further studies are required on the long-term efficacy of PAE.

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