Prostate Artery Embolization Techniques

An evidence-based review of technique recommendations for prostate artery embolization.

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Lower urinary tract (LUT) symptoms are an extremely common issue for men, with the most typical cause in middle and older age men being benign prostatic hyperplasia (BPH).[1] Symptomatic BPH affects as many as 430 per 1,000 men aged 60 to 69 years,[1] with an overall estimated prevalence of 33% in men aged 40 to 80 years in the United States.[2] BPH leads to both a decline in urinary-associated and overall quality of life (QOL).[3,4] This condition results in significant economic burden, with 8 million visits made to physicians with a primary or secondary diagnostic code of BPH reported in the United States in 2000.[5] The estimated cost was $1.1 billion, without factoring in the cost of pharmaceuticals, as well as up to 38 million hours in lost productivity/time.[5]

Initial therapy for symptomatic BPH is medication, typically 5-α-reductase inhibitors or α-blockers. However, for many patients, this is not sufficient, and operative or minimally invasive intervention is needed. Prostate artery embolization (PAE) has been developed as a minimally invasive means to treat BPH-related LUT symptoms. Initial early and midterm results have been very promising in reducing LUT symptoms and improving QOL.[6-30] However, given its early developmental stage, PAE still requires further investigation. Specifically, many aspects of the technique itself have yet to be thoroughly investigated with regard to maximizing treatment safety and efficacy, both of which are paramount in the development of any new technique. This article reviews the current evidence for specific technique recommendations in PAE.

BILATERAL VERSUS UNILATERAL PROSTATIC ARTERY TREATMENT

The logic that bilateral PAE leads to improved size reduction and superior symptomatic outcomes has made bilateral treatment the goal for early investigators studying PAE. This clinical suspicion has specifically been evaluated by a single retrospective study that investigated outcomes in 122 patients treated with polyvinyl alcohol (PVA).[6] The study compared 103 patients who underwent bilateral PAE to 19 who underwent unilateral PAE. They did not demonstrate significant differences in terms of International Prostate Symptom Score (IPSS), maximum flow rate (Qmax), or QOL improvements between the unilateral and bilateral PAE groups. However, they did show that poor outcomes (defined as an IPSS ≥ 20 and/or reduction < 25%, QOL ≥ 4 and or reduction < 1, Qmax < 2.5 mL/s, and additional treatments required [ie, medication or surgery]) were seen more in the unilateral group compared to the bilateral group. However, the statistical significance of this difference ($P < .05$) was lost when age was taken into account. Although this study did not show overwhelming proof that bilateral treatment is superior to unilateral treatment, it suggests a benefit to bilateral treatment without evidence of increased risk.

The issue of bilateral versus unilateral PAE was also one of the variables investigated in a retrospective review of two phase 2 prospective cohorts evaluating the recurrence of LUT symptoms at 12 months.[31] This study presented data on 97 patients and recurrence of symptoms was defined as IPSS ≥ 8 or QOL ≥ 3 at 12 months. Although the primary goal was to investigate the difference between two embolization techniques (the proximal embolization first, then embolize distal for benign prostatic hyperplasia [PErFecTED] technique and original PAE discussed below), they did note that the symptom recurrence was significantly more common with original PAE when only a single prostatic artery was embolized. The same was not true for the PErFecTED technique, but this may have been because only one patient in this group underwent unilateral PAE.

In a recent case series, Amouyal et al reported on the use of bilateral PAE from a single-sided approach.[32] In this series of three patients, intraprostatic anastomoses allowed the authors to pass a microcatheter from one prostatic artery across the prostate to the contralateral prostatic artery and perform embolization. Although previous anatomic studies have shown the presence of such anastomoses, this is the first report of their clinical utility. This interesting series may

provide a guide to achieving bilateral PAE in patients who have arterial occlusion on one side, preventing prostatic artery cannulation.

USE OF CONE-BEAM CT

Cone-beam CT (CBCT) allows increased spatial resolution to be obtained in real time. This powerful technique has led many to advocate for its use to help delineate the arterial anatomy in this complex anatomic region. Two retrospective studies have evaluated the usefulness of CBCT.[33,34] In the first study, Bagla et al performed CBCT on 11 patients and found that CBCT provided information that altered treatment in five of 11 (46%) patients.[33] CBCT altered management by demonstrating collaterals that would have placed the patient at risk of nontarget embolization, as well as identifying duplicate arterial supply not seen on digital subtraction angiography (DSA) that could be pursued for treatment.

In the second study, Wang et al reviewed 148 patients with a primary goal of delineating anatomy.[34] However, the authors also evaluated the value added by CBCT. They discovered that the origins of the prostatic artery could be confidently identified in 94.7% of patients using CBCT as compared to 74.5% using only DSA. They also identified significantly more prostatic artery anastomoses ($P < .05$) with CBCT compared to DSA. In total, they found that CBCT provided more anatomic information, as compared to DSA alone in 95 of 148 (64.2%) patients. These data have helped to confirm the prevailing thought that CBCT provides valuable information, and this theory has largely been adopted by the authors.

PARTICLE SIZE AND TYPE

The published experience using different sizes of treatment embolization particles has widely varied from 50 µm to 300 µm to 500 µm.[6-29] Two studies have specifically addressed this subject.[28,29] The first study by Bilhim et al was a prospective randomized comparison of different PVA sizes.[28] This study compared 80- to 180-µm PVA treatments to 180- to 300-µm PVA treatments and enrolled 80 patients. There was no significant difference in the adverse events experienced between the two groups. The larger particle cohort had a greater reduction in IPSS at 6 months (7.31 vs 3.64), which was found to be nearly significant ($P = .052$). Similarly, QOL improved more in the larger particle group, with an improvement of 1.2 points compared to 0.57 points in the smaller particle group; however, this was not significantly different ($P = .07$). There were also nonsignificant trends of improvement in reduction of prostate volume and postvoid residual (PVR) urine volume in the smaller particle group. The only statistically significant difference was in the reduction of the prostate-specific antigen (PSA) level, which was greater in the small particle group ($P < .05$).

In the second study by Goncalves et al,[29] 15 patients were prospectively treated with 300- to 500-µm trisacryl gelatin microspheres (Embosphere microspheres, Merit Medical Systems, Inc.), and another 15 were treated with 100- to 300-µm microspheres. They found no significant difference in IPSS reduction, QOL improvement, PSA reduction, or prostate size reduction between the two groups. No patients experienced a major adverse event; however, there was a nonstatistically significant trend toward increased minor adverse events in patients who underwent PAE with smaller microspheres ($P = .066$). The smaller particle size also demonstrated a significant regrowth in prostate size from 3 to 12 months, which was not observed in the larger particle size group. These differences led the authors to suggest that the larger particles would be preferable.

Although there are limited data available, both studies have suggested that larger particles (180- to 300-µm PVA and 300- to 500-µm trisacryl gelatin microspheres) tend to perform slightly better. However, these studies are difficult to compare given the difference in particle type, with one using PVA and the other using spherical trisacryl gelatin microspheres. Also, the larger particles performed better in different ways, with the larger PVA particles showing a trend toward improved outcomes and the larger trisacryl gelatin microspheres showing a trend toward decreased adverse events and reduced prostatic regrowth. These differences underline the importance of investigating the optimal type of particle to use. As was experienced in uterine artery embolization (UAE), the type of particle can have a significant impact on outcomes.[35] These data relating to PAE are currently lacking and should be considered for future investigations.

THE PERFECTED TECHNIQUE

The PErFecTED technique as described by Carnevale et al[36] constitutes embolizing the prostatic artery to near stasis after passing all collateral arteries, then the microcatheter is advanced deeper into the parenchymal branches, which are then embolized to complete stasis. This is compared to original PAE, in which the prostatic artery is embolized to stasis after passing all collateral arteries, without advancement into each parenchymal prostatic artery branch. The use of vasodilators prior to embolization is a frequent practice in both techniques and is likely a good practice to help reduce vasospasm and maximize embolic delivery.

The PErFecTED technique has been compared to original PAE in two studies thus far. In the first study, the PErFecTED technique was compared to original PAE in 30 patients who were prospectively enrolled but not randomized. The

PErFecTED technique was found to be superior in IPSS reduction and Qmax improvement at 12 months as compared to original PAE ($P < .05$).[27] However, this study did not show a significant difference in QOL or PVR between the two PAE techniques.

A second study retrospectively reviewed prospectively maintained phase 2 data in 105 consecutive patients who underwent PAE.[34] Of these 105 patients, 12-month data were available for 97. Clinical recurrence was defined as IPSS ≥ 8 or QOL ≥ 3 at 12 months, and 13 of 59 (22%) of original PAE patients and two of 38 (5.3%) of PErFecTED PAE patients had symptom recurrence, with a difference that was found to be statistically significant ($P = .026$). Although large randomized controlled trial data are lacking, it appears that the PErFecTED technique provides superior results compared to simple embolization.

CONCLUSION

PAE has shown promising results at short-term and midterm follow-up. Although we continue to investigate this technique, many areas need to be further evaluated to achieve the goal of procedural optimization. Basic technical aspects, such as the ideal embolization particle, remain unclear. However, the available data seem to support the use of CBCT, particles ≥ 200 µm, the PErFecTED technique, and bilateral PAE. In the future, these aspects warrant further investigation, ideally in a prospective randomized fashion. ■

1. Garraway WM, Collins GN, Lee RJ. High prevalence of benign prostatic hypertrophy in the community. Lancet. 1991;338:469-471.
2. Girman CJ, Epstein RS, Jacobsen SJ, et al. Natural history of prostatism: impact of urinary symptoms on quality of life in 2115 randomly selected community men. Urology. 1994;44:825-831.
3. Yoshimura K, Arai Y, Ichioka K, et al. Symptom-specific quality of life in patients with benign prostatic hyperplasia. Int J Urol. 2002;9:485-490.
4. Hunter DJ, McKee M, Black NA, Sanderson CF. Health status and quality of life of British men with lower urinary tract symptoms: results from the SF-36. Urology. 1995;45:962-971.
5. Wei JT, Calhoun E, Jacobsen SJ. Urologic diseases in America project: benign prostatic hyperplasia. J Urol. 2008;179(5 suppl):S75-S80.
6. Bilhim T, Pisco J, Rio Tinto H, et al. Unilateral versus bilateral prostatic arterial embolization for lower urinary tract symptoms in patients with prostate enlargement. Cardiovasc Intervent Radiol. 2013;36:403-411.
7. Li Q, Duan F, Wang MQ, et al. Prostatic arterial embolization with small sized particles for the treatment of lower urinary tract symptoms due to large benign prostatic hyperplasia: preliminary results. Chin Med J (Engl). 2015;128:2072-2077.
8. Pisco JM, Rio Tinto H, Campos Pinheiro L, et al. Embolisation of prostatic arteries as treatment of moderate to severe lower urinary symptoms (LUTS) secondary to benign hyperplasia: results of short- and mid-term follow-up. Eur Radiol. 2013;23:2561-2572.
9. Pisco JM, Pinheiro LC, Bilhim T, et al, Prostatic arterial embolization to treat benign prostatic hyperplasia. J Vasc Interv Radiol. 2011;22:11-19.
10. Pisco JM, Pinheiro L, Bilhim T, et al. Further evaluation of prostaic artery embolization of symptomatic benign prostatic hyperplasia in a large series of patients. Safety, sort and medium term outocmes [Annual Meeting Society of Interventional Radiology abstract 78]. J Vasc Interv Radiol. 2012;23(suppl):S34-S35.
11. Pisco J, Campos Pinheiro LC, Bilhim T, et al. Prostatic arterial embolization for benign prostatic hyperplasia: short- and intermediate-term results. Radiology. 2013;266:668-677.
12. Pisco JM, Bilhim T, Pinheiro LC, et al. Medium- and long-term outcome of prostate artery embolization for patients with benign prostatic hyperplasia: results in 630 patients. J Vasc Interv Radiol. 2016;27:1115-1122.
13. Pisco J, Bilhim T, Pinheiro LC, et al. Prostate embolization as an alternative to open surgery in patients with large prostate and moderate to severe lower urinary tract symptoms. J Vasc Interv Radiol. 2016;27:700-708.
14. Antunes AA, Carnevale FC, da Motta Leal Filho JM, et al. Clinical, laboratorial and urodynamic findings of prostatic artery embolization for the treatment of urinary retention related to benign prostatic hyperplasia. A prospective single-centeer pilot study. Cardiovasc Intervent Radiol. 2013;36:978-986.
15. Bagla S, Martin CP, van Breda A, et al. Early results from a United States trial of prostatic artery embolization in the treatment of benign prostatic hyperplasia. J Vasc Interv Radiol. 2014;25:47-52.
16. Grosso M, Balderi A, Arno M, et al. Prostatic artery embolization in benign prostatic hyperplasia: preliminary results in 13 patients. Radiol Med. 2015;120:361-368.
17. Kurbatov D, Russo GI, Lepetukhin A, et al. Prostatic artery embolization for prostate volume greater than 80 cm3: results from a single-center prospective study. Urology. 2014;84:400-404.
18. Wang MQ, Guo LP, Zhang GD, et al. Prostatic arterial embolization for the treatment of lower urinary tract symptoms due to large (>80 mL) benign prostatic hyperplasia: results of midterm follow-up from Chinese population. BMC Urol. 2015;15:33.
19. Wang MQ, Wang Y, Yan JY, et al. Prostatic artery embolzation for the treatment of symptomatic benign prostatic hyperplasia in men ≥ 75 years: a prospective single-center study. World J Urol. 2016;34:1275-1283.
20. Amouyal G, Thiounn N, Pelllerin O, et al. Clinical results after prostatic artery embolization using the PErFecTED technique: a single-center study. Cardiovasc Intervent Radiol. 2016;39:367-375.
21. Carnevale FC, Antunes AA, da Motta Leal Filho JM, et al. Prostatic artery embolization as a primary treatment for benign prostatic hyperplasia: preliminary results in two patients. Cardiovasc Intervent Radiol. 2010;33:355-361.
22. Carnevale FC, da Motta Leal Filho JM, Antunes AA, et al. Midterm follow-up after prostate embolization in two patients with benign prostatic hyperplasia. Cardiovasc Intervent Radiol. 2011;34:1330-1333.
23. Carnevale F, da Motta Leal Filho JM, Antunes AA, et al. Quality of life and clinical symptom improvement support prostatic artery embolization for patients with acute urinary retention due to benign prostatic hpyerplasia. J Vasc Interv Radiol. 2013;24:535-542.
24. de Assis AM, Moreira AM, de Paula Rodrigues VC, et al. Prostatic artery embolization for treatment of benign prostatic hyperplasia in patients with prostates > 90 g: a prospective single-center study. J Vasc Interv Radiol. 2015;26:87-93.
25. Gao YA, Huang Y, Zhang R, et al. Benign prostatic hyperplasia: prostatic arterial embolization versus transurethral resection of the prostate—a prospective, randomized, and controlled clinical trial. Radiology. 2014;270:920-928.
26. Bilhim T, Bagla S, Sapoval M, et al. Prostatic arterial embolization versus transurethral resection of the prostate for benign prostatic hyperplasia. Radiology. 2015;276:310-311.
27. Carnevale FC, Iscaife A, Yoshinaga EM, et al. Transurethral resection of the prostate (TURP) versus original and PErFecTED prostate artery embolization (PAE) due to benign prostatic hyperplasia (BPH): preliminary results of a single center, prospective, urodynamic-controlled analysis. Cardiovasc Intervent Radiol. 2016;39:44-52.
28. Bilhim T, Pisco J, Campos Pinheiro L, et al. Does polyvinyl alcohol particle size change the outcome of prostatic arterial embolization for benign prostatic hyperplasia? Results from a single-center randomized prospective study. J Vasc Interv Radiol. 2013;24:1595-1602.
29. Goncalves OM, Carnevale FC, Moreira AM, et al. Comparative study using 100-300 versus 300-500 µm microspheres for symptomatic patients due to enlarged-BPH prostates. Cardiovasc Intervent Radiol. 2016;39:1372-1378.
30. Yu SC, Cho CC, Hung EH, et al. Prostate artery embolization for complete urinary outflow obstruction due to benign prostatic hypertrophy. Cardiovasc Intervent Radiol. 2017;40:33-40.
31. Carnevale FC, Moreira AM, Harward SH, et al. Recurrence of lower urinary tract symptoms following prostate artery embolization for benign hyperplasia: single center experience comparing two techniques. Cardiovasc Intervent Radiol. 2017;40:366-374.
32. Amouyal G, Pellerin O, Del Giudice C, et al. Bilateral arterial embolization of the prostate through a single prostatic artery: a case series [published online December 20, 2016]. Cardiovasc Intervent Radiol.
33. Bagla S, Rholl KS, Sterling KM, et al. Utility of cone-beam CT imaging in prostatic artery embolization. 2013;24:1603-1607.
34. Wang MQ, Duan F, Yuan K, et al. Benign prostatic hyperplasia: cone-beam CT in conjunction with DSA for identifying prostatic arterial anatomy. Radiology. 2017;282:271-280.
35. Golzarian J, Lang E, Hovespian D, et al. Higher rate of partial devascularization and clinical failure after uterine artery embolization for fibroids with spherical polyvinyl alcohol. Cardiovasc Intervent Radiol. 2006;29:1-3.
36. Carnevale FC, Moreira AM, Antunes AA. The "PErFecTED technique": proximal embolization first, then embolize distal for benign prostatic hyperplasia. Cardiovasc Intervent Radiol. 2014;37:1602-1605.

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