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TECHNICAL NOTE

Adjunctive Coil Embolization of the Prostatic Arteries After Particle Embolization for Prostatic Artery Embolization

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Abstract
Purpose To describe the feasibility, safety and short-term results of prostatic artery embolization (PAE) performed with adjunctive coil embolization of the main prostatic arteries (PA) following particle embolization.
Materials and Methods A total of 95 patients who underwent PAE with adjunctive bilateral coil embolization of the PAs following particle embolization between September 2018 and May 2021 were included. The patients had a mean prostate size of 115 ± 64 ml, 18/95 with hematuria symptoms, and 16/95 with indwelling urinary catheters. Coil embolization was performed in the main PAs prior to the bifurcation into the anteromedial and posterolateral branches using detachable microcoils. International Prostate Symptoms Score (IPSS), quality of life (QOL), maximum flow rate (Qmax) and adverse events were recorded.
Results IPSS were improved by − 11.2 ± 7.9 (n = 49, $P < 0.001$) and QOL by − 2.4 ± 1.8 (n = 49, $P < 0.001$) over a mean follow-up of 10.7 ± 7.9 weeks. Qmax did not demonstrate statistical significance. Twelve patients with hematuria (67%) showed improvement or resolution and twelve patients with indwelling or intermittent catheters (75%) were no longer catheter dependent. Two patients underwent a repeat PAE. There were no adverse events which were attributable to coil embolization.
Conclusion Adjunctive coil embolization of the main PAs following particle embolization is a technically feasible technique with similar short-term clinical outcomes compared to prior studies. This novel technique warrants further prospective investigation with controls.

Keywords Prostate artery embolization · Coil embolization · Benign Prostatic Hyperplasia

Introduction

Despite the documented efficacy of prostatic artery embolization (PAE) for benign prostatic hyperplasia (BPH) [1, 2], clinical recurrence occurs in 5–28% of cases [3–6]. In repeat PAEs, the primary pattern for revascularization of the prostate is via recanalization of the main prostatic artery (PA), occurring in 75–80% of cases and as early as four weeks after PAE [7–9]. Given PA revascularization is the most likely culprit for clinical recurrence, a more definitive embolization with additional embolic material has been suggested to minimize recanalization [8, 10]. While the majority of operators perform PAE solely with particles, the use of gelfoam as an adjunct has been previously described [11]. There has been limited investigation into PA coil embolization, largely due to the technical difficulty if a repeat PAE is required. The purpose of this study is to describe the short-term outcomes and safety profile of PAE with particle embolization followed by coil embolization of the main PAs.

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Methods

Patient Selection

This institutional review board-approved retrospective study includes 98 patients from September 2018 to May 2021, during which the standard technique used by the operators included adjunctive coil embolization of the PAs after particle embolization. Three patients with a prior PAE were excluded from data analysis. Baseline patient data includes a mean patient age of 69.3 ± 7.9 years (n = 95), prostate volume 115 ± 64 ml (n = 81), International Prostate Symptoms Score (IPSS) 20.0 ± 7.1 (n = 83), quality of life (QOL) 4.4 ± 1.4 (n = 84), and maximum flow rate (Qmax) 7.6 ± 4.5cm^3/s (n = 50). 18/95 (19%) patients had hematuria, 16/95 (17%) had indwelling urinary catheters, and 5/95 (5%) were dependent on intermittent catheterization. Data were abstracted from a Health Insurance Portability and Accountability Act compliant database.

PAE Procedural Details

All procedures were performed by two operators, each with nine years of prior interventional radiology experience. Intravenous antibiotics, 30 mg keterolac, and 10 mg dexamethasone were administered during the procedure. Post-procedure non-steroidal anti-inflammatory drugs and oral antibiotics were given based on operator preference and prior urine sensitivities.

Digital subtraction angiography and cone-beam computed tomography were used to identify the PAs. Bilateral particle embolization of the PAs was performed via a microcatheter prior to the bifurcation into the anteromedial and posterolateral branches with 250 μm Embozene (Boston Scientific, Marlborough, MA), 100–300 μm Embosphere (Merit Medical, South Jordan, UT) or 200 μm Hydropearl (Terumo, Tokyo, Japan) particles to stasis or near stasis using one of the following microcatheters: Sniper 2.2-Fr balloon occlusion microcatheter (Embolx, Sunnyvale, California), Progreat 2.4-Fr (Terumo), Progreat Alpha 2.0-Fr (Terumo), MicroVention 1.7-Fr angled microcatheter (Terumo), and TruSelect 2.0-Fr (Boston Scientific). This was followed by coil embolization of the PAs through the microcatheter from the same position of particle embolization using one of the following detachable microcoils: Penumbra SMART coil (Penumbra, Alameda, CA), Concerto coil (Medtronic, Minneapolis, MN), Azur CX coil (Terumo) or Interlock soft coil (Boston Scientific) (Fig. 1). In general, two to three microcoils ranging from 2–3 mm in diameter and 4–6 cm in length were required for stasis to be achieved with a dense coil pack.

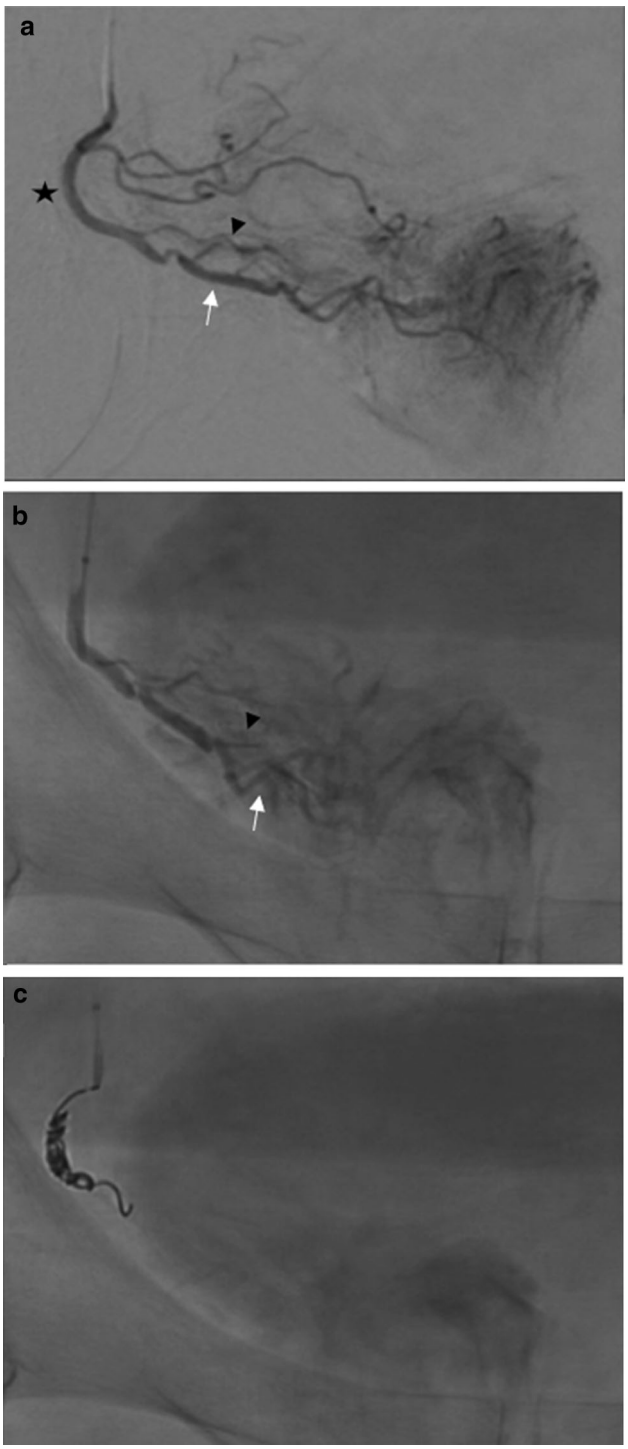

Fig. 1 **a** Selective right PA angiogram under ipsilateral oblique projection. Prostatic artery branches arising from a common trunk. Prostatic artery (*black star*); anteromedial branch (*white arrow*); posterolateral branch (*black arrowhead*) **b** Particle embolization of the right PA via the microcatheter proximal to the bifurcation of the anteromedial and posterolateral branches to near stasis **c** Placement of detachable microcoils in the right main PA with microcatheter in stable position proximal to the bifurcation of the anteromedial and posterolateral branches

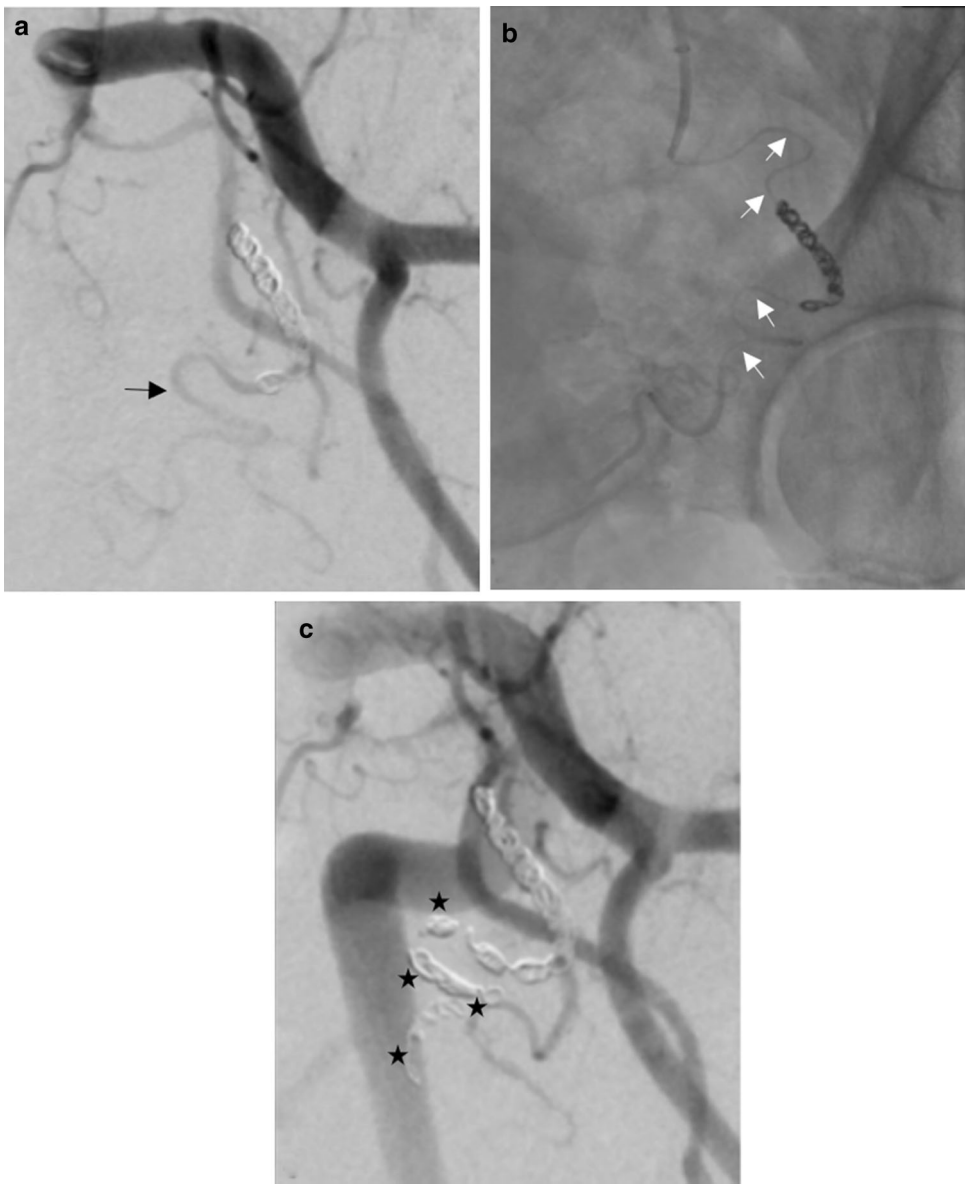

Fig. 2 77-year-old male status post PAE with coil embolization of the PAs with recurrent hematuria presenting for repeat PAE **a** Digital subtraction angiogram of the left PA demonstrating persistent antegrade flow in the PA distal to the coil pack (*black arrow*) **b** Catheterization of the PA distal to the existing coil pack with a microcatheter (*white arrows*) **c** Digital subtraction angiogram of the left PA after additional coil embolization (*black stars*) without flow through the main PA

Statistical Analysis

The analysis was conducted with SPSS version 24.0 software (SPSS, Chicago, Illinois) for Windows (Microsoft, Redmond, Washington). Two-sided P values < 0.05 were considered to be statistically significant.

Results

Over a follow-up of 10.7 ± 7.9 weeks for the study population with complete data, 47/49 (96%) had reduction in IPSS score and 44/49 (90%) had reduction in QOL score. For patients with follow-up < 6 weeks, IPSS improved from 18.8 ± 8.4 to 10.5 ± 6.0 ($n = 21$, $P < 0.001$) and QOL improved from 4.2 ± 1.6 to 2.3 ± 1.8 ($n = 23$, $P < 0.001$). For patients with follow-up > 18 weeks, IPSS improved from 18.9 ± 5.1 to 8.3 ± 4.9 ($n = 10$, $P < 0.001$) and QOL improved from 3.6 ± 1.4 to 1.5 ± 0.8 ($n = 10$, $P < 0.001$) with a mean follow-up of 24 weeks. Qmax improved from 6.9 ± 3.6 to 9.1 ± 4.4 cm^3/s ($n = 15$, $p = 0.15$). Of patients with follow-up, 10/13 (77%) patients with an indwelling urinary catheter had their catheters removed, the majority of which were removed within four weeks after PAE. In addition, both patients with intermittent catherization with follow-up were no longer catheter dependent. At follow-up, 12/14 (86%) patients with pre-PAE hematuria had improvement or complete resolution of hematuria.

Minor adverse events without sequelae include eight cases of dysuria (8%), eight cases of urinary frequency (8%), three cases of hematospermia (3%) and two cases of urinary retention (2%). There were three severe adverse events (3%) in our study population. One episode of glans penis ulceration attributable to non-target particle embolization resolved with conservative management. One patient with a thoracic aortic dissection attributed to propagation of a dissection flap from a transradial approach underwent thoracic endovascular aortic repair with complete resolution of symptoms. One episode of left radial artery occlusion improved after a 7-day course of rivaroxaban. No adverse events were attributed specifically to coil embolization of the PAs.

Within the study cohort, repeat PAE was performed for two patients. In a patient with recurrent hematuria, repeat PAE at two months demonstrated that the left PA coil pack was non-occlusive. Technical success was achieved with catheterization of the PA distal to previous coil embolization (Fig. 2) with resolution of hematuria. In another patient with persistent nocturia, repeat PAE at five months demonstrated prostate revascularization was via the left pudendal artery and right posterior-lateral PA branch without recanalization of the main PAs.

Discussion

With data suggesting that symptom recurrence after PAE is predominantly from the recanalization of the main PA and occurs as early as four weeks [7–9], more durable strategies of embolization such as coil embolization of the main PAs should be an investigative priority. In this study, the short-term outcomes of adjunctive PA coil embolization following particle embolization are similar to the reported literature for PAE without PA coil embolization.

PA coil embolization has high technical success, without a single case of unsuccessful coil placement when the PAs were catheterized or evidence of coil migration into non-target vessels. In the study cohort, there were no adverse events attributed to PA coil embolization, with similar rates of adverse events to prior studies. Two repeat PAEs were performed, both of which had technical success and clinical improvement. Further study will be required to establish whether PAE with adjunctive coil embolization of the PAs decreases clinical recurrence and need for repeat PAE and whether there is increased technical failure of repeat PAEs. In addition, the increased cost of coil embolization should be considered, with the detachable microcoil cost ranging from $375–1070 USD. Pushable microcoils were deemed suboptimal by the operators given the precision of placement needed in these small tortuous vessels.

This study has several limitations such as its retrospective nature, short follow-up and lack of a control group. The number of patients without follow-up data is a limitation, with decreased in-person follow-up during the COVID-19 pandemic. For these reasons, this technique warrants future prospective investigation with controls and long-term data to establish the potential benefit of decreased symptom recurrence.

Conclusion

This study demonstrates that adjunctive PA coil embolization following particle embolization in PAE is a technically feasible and safe technique with comparable short-term outcomes to previous studies without PA coil embolization. This novel technique warrants further prospective investigation with controls.

Author Contributions RA Lookstein, MD is a paid consultant for Medtronic and Boston Scientific; on the advisory board for Medtronic, Summa Medical, and Boston Scientific; and a speaker for Abbott Vascular. AM Fischman, MD is a paid consultant for Terumo and Boston Scientific; on the advisory board for Terumo, Embolx, and Boston Scientific; a speaker for Terumo and Boston Scientific; provided research support from Boston Scientific; has a royalty agreement with Merit Medical; and is an investor in Adient Medical.

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Declarations

Conflict of interest Naveen Galla, Samuel Maron, Nicholas Voutsinas, Alex Sher, Matthew Tangel, Joshua Jue, Himanshu Sharma, and Ardeshir Rastinehad declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent For this type of study, informed consent is not required. This study has obtained IRB approval from our institution and the need for informed consent was waived. This study has obtained IRB approval from our institution and for this type of study formal consent is not required.

Consent for Publication For this type of study, consent for publication is not required.

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