CLINICAL STUDY

Prostatic Artery Embolization with 250-μm Spherical Polyzene-Coated Hydrogel Microspheres for Lower Urinary Tract Symptoms with Follow-up MR Imaging

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ABSTRACT

Purpose: To evaluate clinical outcomes and possible MR imaging predictors of clinical success after prostatic artery embolization (PAE) with 250-μm hydrogel particles.

Materials and Methods: During a span of 1.5 years, 30 patients with moderate to severe lower urinary tract symptoms were included in a prospective, nonrandomized study. Embolization of at least one prostatic artery was considered as technical success. International Prostate Symptom Score (IPSS), quality of life (QOL), peak urinary flow rate (Q_{max}), residual urine volume, prostate volume, prostate-specific antigen level, and International Index of Erectile Function (IIEF) were recorded at baseline and at 1, 3, and 6 months after PAE. Multiparametric MR imaging was performed before PAE (n = 25) and 1 day (n = 25), 1 month (n = 7), 3 months (n = 7), and 6 months (n = 22) after intervention. A Wilcoxon–Mann–Whitney test was used to assess changes over time, and Spearman rank-correlation coefficient was used for outcome prediction.

Results: PAE was technically successful in 90% of patients (n = 27). Clinical success (IPSS $<$ 18 with decrease $>$ 25% and QOL score $<$ 4 with decrease $\geq$ 1 or $Q_{max} \geq$ 15 mL/s and increase of $\geq$ 3.0 mL/s) rates were 59% (16 of 27), 63% (17 of 27), and 74% (20 of 27) after 1, 3, and 6 mo, respectively. IIEF scores did not differ significantly during follow-up. The following adverse events occurred after PAE: urethral burning (5 of 27), fever (2 of 27), and urethral bleeding, rectal bleeding, cystitis, and penile burning sensation (1 of 27 each). No statistical correlations between initial multiparametric MR imaging changes and clinical parameters after 6 months were found (*P* values from .14 to .98).

Conclusions: PAE with 250-μm hydrogel microspheres led to good clinical success after 6 months with a low complication rate. Significant MR imaging predictors of clinical success were not identified.

ABBREVIATIONS

ADC = apparent diffusion coefficient, BPH = benign prostatic hyperplasia, BPS = benign prostate syndrome, DWI = diffusion-weighted imaging, IIEF = International Index of Erectile Function, IPSS = International Prostate Symptom Score, k_{ep} = rate constant, K^{trans} = transfer constant, LUTS = lower urinary tract symptoms, PAE = prostatic artery embolization, PSA = prostate-specific antigen, Q_{max} = peak urinary flow rate, QOL = quality of life, TSE = turbo spin-echo, v_e = extravascular, extracellular volume

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EDITORS' RESEARCH HIGHLIGHTS

- Prostatic artery embolization (PAE) with the use of spherical 250-μm-sized Polyzene-coated hydrogel particles was safe and effective in relieving lower urinary tract symptoms in patients (N = 30) with benign prostatic hyperplasia.
- Quantification of perfusion and diffusion changes with MR imaging 1 day after PAE (n = 25) was able to depict prostate tissue ischemia to be more pronounced in the central gland than in the peripheral zone. Interestingly, ischemic changes shown on MR imaging at 1 day disappeared after 1 month.
- Quantification of perfusion and diffusion parameters with MR at baseline and follow-up after embolization failed to correlate with clinical outcomes or with prostate volume reduction after embolization.
- The sample size was relatively small (N = 30), no quantification of prostate ischemia volume was performed, and the statistical analysis plan used no multivariate regression models to control for confounding.

Prostatic artery embolization (PAE) has developed in the past 10 years as aminimally invasive interventional radiologic alternative to the established urologic therapies for lower urinary tract symptoms (LUTS) related to benign prostatic hyperplasia (BPH) (1–3). Several meta-analyses (1–3) showed significant improvement of established functional outcome measures such as the International Prostate Symptom Score (IPSS), quality of life (QOL), peak urinary flow rate (Q_{max}), and postvoid residual volume after PAE, whereas International Index of Erectile Function (IIEF) scores remained unchanged. Previous studies (4–11) have investigated nonspherical 50–500-μm polyvinyl alcohol particles, spherical 300–500-μm polyvinyl alcohol particles, 100–500-μm trisacryl gelatin microspheres, and 100–400-μm Polyzene-coated hydrogel microspheres.

Polyzene-coated hydrogel microspheres are spherical, biocompatible, nonresorbable microspheres that undergo approximately 30% compression through a microcatheter before returning to their spherical shape. In addition, the microspheres have a tight size distribution within each vial. For example, 250-μm Embozene microspheres (Boston Scientific, Marlborough, Massachusetts) have a size distribution of ±50 μm, with 95% of the microspheres within this range (200–300 μm). In animal testing, these characteristics of in vivo deformation and precise calibration contributed to deep and homogenous penetration into the vascular bed (12). Clinical effects of these embolization particles have been described in 2 published studies (4,10). In the first study (10), 33 patients were treated with 400-μm particles, and, in the second trial (4), 78 patients were treated with 100-, 250-, or 400-μm particles. No determination of clinical success was made based on the particle size applied.

After PAE, prostate tissue shows signs of inflammation through ischemic necrosis with surrounding stromal lymphocytes (13). T1- and T2-weighted magnetic resonance (MR) images, as well as diffusion-weighted imaging (DWI) and dynamic contrast-enhanced MR imaging, allow the representation and quantification of ischemic areas. T2-weighted images appear blurred because of inflamed tissue caused by edema. T1-weighted images show eventual bleeding in the necrosis because of T1-shortening effects of hyperintense blood degradation products (14,15). Compared with other imaging methods, DWI detects ischemia in the brain most sensitively at a maximum of 24 hours after thromboembolic occlusion (16). The signal intensity of dynamic contrast-enhanced MR imaging depicted ischemic infarcts 1–3 months after PAE as areas with no evident enhancement after contrast agent administration (9,15,17).

An MR imaging trial (18) of the effectiveness of uterine artery embolization on uterine and leiomyoma perfusion demonstrated that, right after embolization, the myometrium and the leiomyoma are not vascularized, whereas the myometrium showed revascularization after 48–72 hours. A contrast-enhanced ultrasound (US) study (19) showed that clinical success 1 day after embolization was predictable through imaging in 4 of 5 patients. Pharmacokinetic models allow the absolute quantification of surrogate parameters of vascularization based on the measured signal intensities of dynamic contrast-enhanced MR imaging. The most known and applied model for this study is the open 2-compartment Tofts model (20) with the parameters transfer constant (K^{trans}), rate constant (k_{ep}), and extravascular, extracellular volume (v_e).

The primary purpose of the present observational study was to determine the success of PAE with spherical, Polyzene-coated 250-μm hydrogel microspheres for patients with moderate to severe LUTS related to BPH, also known as benign prostate syndrome (BPS). A second objective was to represent ischemic changes in the prostate after PAE and quantify them on MR imaging. Finally, we tested whether the tissue changes observed on posttherapeutic MR imaging 1 day after PAE could predict clinical success 6 months later.

MATERIALS AND METHODS

This study was approved by the local ethics committee and was registered at *Clinicaltrials.gov* (identifier NCT02206243).

Inclusion and Exclusion Criteria

Consecutive patients aged more than 45 years with moderate to severe LUTS were included in the study. The inclusion criteria required patients to have an IPSS $\geq$ 18 and/or Q_{max} $\leq$ 15 mL/s or a permanent catheter, be refractory to BPS medication therapy for at least 6 months or refuse BPS medication therapy, and have a prostate volume of $\geq$ 30 mL.

The exclusion criteria were the presence of prostate cancer, acute infection (eg, prostatitis, urethritis), urethral stricture, neurogenic bladder, large bladder diverticula or stones, vessel changes preventing PAE, and estimated glomerular filtration rate < 60 mL/min.