Seminal vesicle abnormalities following prostatic artery embolization for the treatment of benign prostatic hyperplasia

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Abstract

Background: Prostatic artery embolization (PAE) has been proved effective in the treatment of lower urinary tracts (LUTS) secondary to benign prostatic hyperplasia (BPH) with low complications, and most of the them are due to non-target embolization of adjacent organs, such as bladder, rectum, seminal vesicles and penis. Aim of this study was to present seminal vesicle (SV) abnormalities following prostatic artery embolization (PAE) for the treatment of symptomatic benign prostatic hyperplasia.

Methods: We reviewed 139 BPH patients who received PAE during the period of February 2009 and January 2015 at a single institution, highlighting seminal vesicle abnormalities and their clinical relevance after PAE. PAE was performed using 90~180–μm (mean 100–μm) polyvinyl alcohol foam particles.

Results: Nine of 139 patients with SV abnormalities (6.5%) were identified by magnetic resonance imaging (MRI), including subacute haemorrhage in 3 patients and ischaemia in 6 patients. Using cone-beam computed tomography (CB-CT), the seminal vesicle arteries were identified 8 of the 9 patients. All 9 patients complained of a few episodes of mild haematospermia during the 1–4 weeks after PAE; the haematospermia disappeared spontaneously without any treatment.

Conclusion: SV haemorrhage and ischaemia may occur after PAE, and these patients may present with transient and self-limited haematospermia.

Keywords: Angiography, Benign prostatic hyperplasia, Prostate artery embolization, Seminal vesicle haemorrhage, Seminal vesicle ischaemia

Background

Prostatic artery embolization (PAE) has been adopted as a minimally invasive therapeutic modality for the treatment of lower urinary tract symptoms (LUTS) following benign prostatic hyperplasia (BPH) [1–10]. However, a recent systematic review suggest that PAE is inferior to standard treatment methods, such as open prostatectomy (OP) or transurethral resection of the prostate (TURP), and PAE is still considered an experimental treatment modality [11]. Complications of PAE are low and are primarily related to non-target embolization of other arteries, such as the vesical, rectal, and dorsal arteries of the penis. Major complications have been rare, with only two cases of bladder focal necrosis [1, 7]. Minor adverse events after PAE have occurred in, cumulatively, 11% of patients [1, 2, 7–10] and have included urinary tract infections, transient haematuria, transient haematospermia, a small amount of rectal bleeding, ischaemic rectitis, and balanitis.

Haematospermia, an uncommon clinical event, has occurred in 5.9–16% of cases after PAE [1, 3, 5, 10]. We hypothesize that haematospermia secondary to PAE may be associated with seminal vesicle (SV) ischaemia and haemorrhage, resulting from non-target embolization. Herein, we report nine cases of SV abnormalities after PAE, including SV ischaemia in 6 patients and SV haemorrhage in 3 patients, identified by magnetic resonance imaging (MRI) follow-up.
Methods

Patients
Between February 2009 and January 2015 in our institution, a total of 139 patients (mean age, 72.0 years ± 10.5 [standard deviation]) diagnosed with moderate or severe LUTS (International Prostate Symptoms Score [IPSS] > 18 points, quality of life [QoL] score > 3, and/or urinary retention with urinary catheter removal failure) due to BPH who were refractory to medical treatment for at least 6 months underwent PAE.

PAE protocols
The selection criteria included patients with a diagnosis of severe LUTS, negative screening for prostate cancer, prostate volume (PV) > 40 mL measured by MRI, and bladder outlet obstruction (BOO) confirmed by urodynamic examination, peak urinary flow rate (Qmax) < 12 mL/sec, and PVR post-void residual urine (PVR) > 150 mL evaluated by ultrasound, biopsy was performed to rule out prostate malignant if PSA level > 4.0 ng/mL. The patient selection was evaluated by a multidisciplinary team that included urologists, anaesthesiologists, and interventional radiologists. Exclusion criteria included pelvic malignancy, chronic renal failure, large bladder diverticula (> 5 cm), active urinary tract infection, large bladder stones (> 2 cm), unregulated coagulation parameters, neurogenic bladder, allergy to intravenous contrast media, detrusor failure and urethral stricture diagnosed through pressure flow studies or urethrography.

The preparative clinical observation included IPSS, QoL, peak urinary flow rate (Qmax), post-void residual volume (PVR), international index of erectile function short form (IIEF-5) score, and PV before PAE and at 1, 3, 6 and every 6 months after the procedure. All patients underwent 1.5-T multiparametric enhanced MRI (GE Healthcare, Milwaukee, Wisconsin, USA) of the prostate to measure PV and to rule out cancer before PAE using a phased-array 12-channel body coil. For each patient, the MRI protocol was the same, including axial, coronal, and sagittal T2-weighted imaging (T2WI) and contrast- and non-contrast enhanced T1-weighted imaging (T1WI).

Embolication technique
The details of the procedure of PAE have been described previously [10]. The PAEs were performed by two senior interventional radiologists (M.Q.W. and K. Y., with 26 and 12 years of vascular and interventional radiology experience, respectively), using a therapeutic angiography unit equipped with a digital flat-panel detector system (INNOVA 4100 IQ; GE Healthcare, Milwaukee, Wisconsin, USA). PAE was performed under local anaesthesia through a single right femoral approach using a 4-Fr vascular sheath (Radifocus, Terumo, Japan). Digital subtraction angiography (DSA) and cone-beam computed tomography (CB-CT) were performed to identify prostatic arteries (PAs). Embolization was performed with 100-μm non-spherical PVA particles (90-180-μm, PVA, Cook Incorporated, Bloomington, IN, USA). The endpoint of embolization was occlusion of the identifiable vessels supplying the prostate.

Follow-up
Follow-up was performed at 1, 3, 6, and every 6 months after PAE by the interventionalists and the urologists. IPSS, QoL, IIEF-5, PSA, Qmax, PVR, and PV on MRI were evaluated at those dates to measure clinical and radiological changes after PAE.

Imaging evaluation
All MR images were assessed independently by two radiologists (reader 1 and reader 2, with 11 years and 15 years of experience in interpreting body MR images, respectively) without knowing the outcomes of the PAE. If there was disagreement, the relevant MR images were reassessed by a third independent reader (reader 3, with 20 years of experience in interpreting body MR) to reach a consensus.

The procedural angiographic images, including DSA, rotational angiography, and CB-CT, were reviewed retrospectively by two interventional radiologists (G. D. Z. and M.Q.W., with 16 and 25 years of vascular and interventional radiology experience, respectively), highlighting the possibility of the blood supplying the SV (“vesiculo-deferential artery”). After independent interpretations were achieved, the differences in evaluations between the two radiologists were resolved by consensus.

Results

Peri-procedural outcomes
Nine cases of SV abnormalities (6.5%) after PAE, including SV ischaemia in 6 patients and SV haemorrhage in 3 patients, were identified by MRI follow-up. The baseline characteristics of the nine patients are provided in Table 1. PAE was performed bilaterally in the 9 patients, identifying a total of 13 prostatic arteries. Of these prostatic arteries, six were originated from the internal pudendal artery, and seven were originated from the gluteal-pudendal trunk. No immediately procedural complications occurred.

Imaging findings
Subacute SV haemorrhage was presented in 3 patients (Patient No. 1, 2, and 3). MRI at 1 month following PAE showed high-intensity signals on T1WI with low-intensity signals on T2WI in the SVs, suggesting typical subacute haemorrhage (Fig. 1a-b). These findings were not presented on the pre-procedural MRI. During the 3- to 12-month follow-up, these high-intensity signals on T1WI within the SVs became iso-intensity signals, with a reduction in the...
size of the SV, suggestive of SV atrophy (Fig. 1c). With retrospective analysis of the intra-procedural angiographic images, the CB-CT images showed that the small arteries branched proximally from the prostate arteries supplied to the SV (i.e., the seminal vesicle arteries) in 3 patients; however, these small arterial branches could not be identified on DSA (Fig. 1d-f).

SV ischaemia was presented in 6 patients (Patient Nos. 4–9). Contrast-enhanced T1WI images at 1 month following PAE showed obvious hypoperfusion in the seminal vesicles, suggestive of ischaemia (Figs. 2, 3 and 4). SV atrophy was also noted in those patients during the follow-up. The SV arteries could be identified in 5 of the 6 patients on the CB-CT but were difficult to identify on DSA.

### Table 1 Clinical Data Obtained before and at 12 Months after PAE (N = 9)

| Patient | IPSS | QoL | PV(ml) | PSA(ng/ml) | Qmax(ml/s) | PVR(ml) | IIEF-5 |
|---------|------|-----|--------|------------|------------|---------|--------|
|         | Pre  | Post| Pre    | Post       | Pre        | Post    | Pre    | Post   | Pre  | Post  | Pre  | Post  | Pre  | Post  | Pre  | Post  | Pre  | Post  |
| 1       | 28   | 6   | 6      | 1          | 79         | 39      | 4.6    | 3.4    | 7.0  | 15.0  | 70   | 0     | 16    | 18    |
| 2       | 26   | 5   | 5      | 0          | 72         | 44      | 3.9    | 3.0    | 8.5  | 16.0  | 50   | 0     | 19    | 19    |
| 3*a    | 32   | 5   | 6      | 1          | 127        | 58      | 8.0    | 3.9    | –    | 14.0  | –    | 10    | 9     | 10    |
| 4       | 30   | 7   | 6      | 2          | 90         | 47      | 3.0    | 3.4    | 6.0  | 14.0  | 80   | 10    | 17    | 15    |
| 5       | 27   | 5   | 5      | 0          | 67         | 37      | 2.0    | 1.5    | 8.0  | 16.0  | 60   | 0     | 16    | 18    |
| 6       | 29   | 8   | 6      | 2          | 116        | 64      | 7.1    | 5.7    | 5.0  | 13.0  | 100  | 10    | 7     | 7     |
| 7       | 28   | 6   | 6      | 1          | 87         | 46      | 4.5    | 3.0    | 7.0  | 15.0  | 90   | 0     | 11    | 12    |
| 8       | 27   | 4   | 6      | 1          | 84         | 52      | 7.0    | 2.0    | 10.0 | 19.0  | 70   | 0     | 18    | 19    |
| 9       | 30   | 6   | 6      | 2          | 122        | 66      | 2.9    | 1.5    | 8.5  | 17.0  | 110  | 0     | 15    | 16    |
| mean    | 28.6 | 6   | 5.8    | 1          | 93.8       | 50.3    | 4.8    | 3.1    | 7.5  | 15.4  | 74.3 | 3.8   | 14    | 15    |

*aPatient with urinary retention before PA

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**Fig. 1** Seminal vesicle haemorrhage. Image from a 65-year-old man with lower urinary tract symptoms due to benign prostatic hyperplasia (BPH). He presented with mild haematospermia at 1 week after PAE that disappeared 4 weeks later without specific treatment. a Axial T1-weighted MR image obtained before PAE shows the normal appearance of the seminal vesicles (arrowheads) and BPH (straight arrow). b Axial T1-weighted MR image obtained 1 month after PAE shows high-intensity signals on the right side of the seminal vesicles (arrowhead), suggestive of haemorrhage, and BPH (straight arrows). c Axial T1-weighted MR image (without fat suppression) obtained 12 months after PAE shows iso-intensity signals on the right side of the seminal vesicles (arrowhead) and reduction in the size of the SVs. d Digital subtraction angiography (DSA) of the right prostatic artery (straight arrow) with same-side anterior oblique projection (35°) demonstrates contrast medium staining in the right prostate lobe (asterisk). e Cone-beam CT (CB-CT) with coronal view after catheterization of the right prostatic artery (straight arrow) demonstrates contrast medium staining in the right prostate lobe (asterisk). f CB-CT with axial view after catheterization of the right prostatic artery (straight arrow) demonstrates the small branches (curved arrow) supplying the seminal vesicles (the seminal vesicle artery) and contrast medium staining in the right prostate lobe (asterisks)
The relevant clinical findings
At the 1-month follow-up visit, all 9 patients complained a few episodes of mild haematospermia during 1–4 weeks after PAE; the haematospermia disappeared spontaneously without any treatment. Four of them had co-occurring mild macroscopic haematuria, but without evidence of bladder ischaemia on the MRI follow-up. Three cases had temporary anxiety due to the haematospermia. The remaining 130 patients had no complaints of haematospermia or haematuria; no abnormalities of the SVs were presented on the follow-up MRI.

The mean follow-up time of the 9 patients was 22 months (range, 14–36 months). The mean IPSS (pre-PAE vs post-PAE 28.6 vs 6.0; \( P < 0.01 \)), QoL (5.8 vs 1.0; \( P < 0.05 \)), Qmax (7.5 vs 15.4; \( P < 0.01 \)), PVR (74 mL vs 4 mL; \( P < 0.01 \)), PV (94 mL vs 40 mL; \( P < 0.05 \)), and PSA (4.8 ng/mL vs 3.1 ng/mL; \( P < 0.05 \)) had significant differences compared with baseline, as shown in Table 1. The mean IIEF-5 had no significant difference from baseline (\( P = 0.8 \)).

Discussion
PAE is a safe and effective procedure with low morbidity in most cases [1, 7–13]. Although various complications of PAE, such as bladder ischaemia, urinary tract infections, balanitis, and ischaemic rectitis, have been reported, seminal vesicle abnormality after PAE is rare [1, 7, 14, 15]. In the present study, the incidence of SV abnormalities (haemorrhage and ischaemia) after PAE, identified by MRI follow-up, was 6.5%. Clinically, patients with SV haemorrhage or ischaemia usually present with haematospermia [16]. Pisco JM et al. [1] reported that transient haematospermia occurred in 7% of cases after PAE. De Assis AM et al. [5] reported that transient and self-limited haematospermia occurred in 5.9% of cases after PAE. Recently, Amouyal G et al. [12] evaluated 32 patients treated with PAE and reported that 3 patients (9%) experienced haematospermia during 3 days to 1 month after PAE. Bagla et al. [3] reported an incidence of 16% (3 of the 19 patients) self-limited haematospermia even using CB-CT.
Haematospermia secondary to PAE may be related to seminal vesicle ischaemia and haemorrhage resulting from non-target embolization. In the present cases, the SV abnormalities could be explained by embolic particle reflux, existence of a common trunk between the prostate capsule branch and the seminal vesicle artery, misidentification of the seminal vesicle artery as a capsular artery, or a prostato- seminal vesicle arterial anastomosis not detected angiographically at the time of embolization.

There is no specific therapeutic option in the treatment of seminal vesicle haemorrhage or ischaemia after PAE. However, bacterial inflammation may occur after bleeding in the seminal vesicles [16]. Therefore, antibiotic treatment is recommended once seminal vesicle haemorrhage or ischaemia has been confirmed by MRI. In addition, haematospermia after PAE may cause the psychological anxiety for the patient; therefore, it is necessary to explain the complication to patients before the procedure.

Knowledge of the detailed anatomy of the pelvic arteries is crucial for a safe and effective PAE and to avoid complications from non-targeted embolization of surrounding organs to yield better outcomes [1, 2, 17]. The blood supplies to the prostate, bladder, rectum, and penis have been reported previously in the literature [18–22]. However, little work appears to have been performed on the anatomy of the arterial circulation in the seminal vesicles; most of the standard textbooks even ignore the existence of a blood supply to this organ. In early studies in cadaveric specimens by Clegg EJ [23], he described that the seminal vesicle arteries were supplied by the “vesiculo-deferential artery”; the origin of this vessel is highly variable and includes the umbilical artery, internal pudendal artery, superior vesical

Fig. 3 Seminal vesicle ischaemia. Image from a 69-year-old patient with lower urinary tract symptoms due to a large BPH (132 mL). a Coronal contrast-enhanced T1-weighted MR image obtained before PAE shows normal seminal vesicles (arrowheads). b Coronal contrast-enhanced T1-weighted MR image obtained at 1 month after PAE shows significant hypoperfusion in the seminal vesicles (arrowheads), suggestive of ischaemia.

Fig. 4 Images from the same patient as Fig. 3. a DSA of the right prostatic artery (curved arrow) with same-side anterior oblique projection (35°) demonstrates contrast-medium staining in the right prostate lobe (asterisk) and the small branches (straight arrow), which were suspected to be the seminal vesicle arteries. b CB-CT with coronal view after catheterization of the right prostatic artery (curved arrow) demonstrates the small branches (straight arrows) supplying the seminal vesicles. c CB-CT with axial view after catheterization of the right prostatic artery (curved arrow) demonstrates the small branches (straight arrows) supplying the seminal vesicles (the seminal vesicle arteries) and contrast medium staining in the prostate (asterisks).
artery, and prostatic vesical artery. Currently, there are no in vivo studies published in the literature documenting the imaging findings of SV artery anatomy.

In the present study, with retrospective reviews using DSA and CB-CT, we could identify the SV arteries, which presented with very small branches on the CB-CT images in 8 of the nine patients, which originated proximally from the prostatic artery. To prevent PAE-related SV complications, more studies are needed to understand the detailed anatomy of the SV arteries. From our experience, CB-CT performed intraoperatively using a three-dimensional arteriography with maximum-intensity projection is a useful tool for PAE procedures. Although the result is a low-quality image compared with that of conventional computed tomography, it provides good vessel identification when vessels cannot be visualized on arteriography [24].

Conclusions

Although the SV abnormalities after PAE were not significant consequences, interventionists should be aware of that non-targeted embolization of the seminal vesicles may be the cause of haematospermia. Long-term follow-up is needed to understand the long-term effects of seminal vesicle haemorrhage or ischaemia.

Abbreviations

BPH: Benign prostatic hyperplasia; CB-CT: Cone-beam computed tomography; DSA: Digital subtraction angiography; IPSS: International Prostate Symptom Score; LUTS: Lower urinary tract symptoms; MRT: Magnetic resonance imaging; PAE: Prostatic artery embolization; PSA: Prostate-specific antigen; PV: Prostate volume; PVA: Polyvinyl alcohol particles; PVR: Post-void residual volume; Qmax: Peak urinary flow rate; QoL: Quality of life

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Availability of data and materials

The datasets supporting the conclusions of this study are available from the corresponding author on reasonable request. Raw data are not available for publication, as they contain identifiable patient variables.

Authors’ contributions

JLZ and KY: Contributed equally to this work and are joint first authors on this article. JLZ and MQW: Study concept and design and interpretation of the imaging data. KY: Acquisition of data. GDZ: Interpretation of clinical and angiographic data. JYY and YW: Analysis and interpretation of clinical data. JLZ and KY: Contributed equally to this work and are joint first authors on this article. JLZ and KY: Contributed equally to this work and are joint first authors on this article. JLZ and KY: Contributed equally to this work and are joint first authors on this article. JLZ and KY: Contributed equally to this work and are joint first authors on this article.

Ethics approval and consent to participate

This study was conducted with the approval of the hospital review boards of the Chinese People’s Liberation Army General Hospital and was performed according to the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Written informed consent was obtained from all of the patients for the PAE procedure. Additional informed consent was not required for this retrospective study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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