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Prostatic Artery Embolization for Lower Urinary Tract Symptoms via Transradial Versus Transfemoral Artery Access: Single-Center Technical Outcomes

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Objective: To evaluate the safety and feasibility of prostatic artery embolization (PAE) via transradial access (TRA) compared with transfemoral access (TFA).

Materials and Methods: This retrospective study included 53 consecutive men with lower urinary tract symptoms (LUTS) who underwent PAE between September 2018 and September 2021. Thirty-one patients (mean age ± standard deviation: 70.6 ± 8.4 years) were treated with TFA, including 14 patients treated before adopting TRA. Since December 2019, TRA has also been attempted with the procedure's selection criteria of patent carpal circulation and a height ≤ 172 cm, with 22 patients treated via TRA (69.1 ± 9.6 years). Parameters of technical success (defined as successful bilateral embolization), clinical success (defined as LUTS improvement), procedural time, radiation dose, and adverse events were compared between the two groups using the Fisher's exact test, independent sample *t* test, Wilcoxon signed-rank test, or Mann-Whitney test.

Results: All patients received at least one-side PAE. Technical success of PAE was achieved in most patients (TRA, 21/22; TFA, 30/31; $p > 0.999$). No technical problem-related conversion from TRA to TFA occurred. The clinical success rate was 85% (11/13) in patients with TRA, and 89% (16/18) in patients with TFA for follow-up > 2 weeks post-PAE (median, 3 months) ($p > 0.999$). The median procedure time was similar in both groups (TRA, 81 minutes vs. TFA, 94 minutes; $p = 0.570$). No significant dose differences were found between the TRA and TFA groups in the dose-area product (median $Gycm^2$, 95 [range, 44–255] for TRA and 84 [34–255] for TFA; $p = 0.678$) or cumulative air kerma (median mGy, 609 [236–1584] for TRA and 634 [217–1594] for TFA; $p = 0.551$). No major adverse events occurred in either of the groups.

Conclusion: PAE via TRA is a safe and feasible method comparable to conventional TFA. It can be safely implemented by selecting patients with patent carpal circulation and adequate height.

Keywords: *Lower urinary tract symptoms; Prostate; Prostatic artery embolization; Percutaneous transcatheter embolization*

INTRODUCTION

Prostatic artery embolization (PAE) is an emerging minimally invasive therapy for lower urinary tract symptoms (LUTS), and the results of many studies have supported its effectiveness [1-3]. Transradial artery access (TRA) for percutaneous intervention is known to have fewer complications at the access site, allows early ambulation and hospital discharge, improves patient satisfaction, and offers potential cost savings compared to transfemoral artery access (TFA) [4,5]. Furthermore, PAE via TRA can provide more advantages for the patient population, because it allows for leg elevation during a potentially long procedure to alleviate lower back pain and early ambulation to help urination, which may be made more difficult by prostate swelling caused by the procedure [6]. These benefits enable the treatment of patients on an outpatient basis. The use of PAE has increased, as evidence of its efficacy has been demonstrated; however, PAE via TRA is not commonly attempted because of unfamiliarity

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with it, and its requirement for lengthy devices [4,7]. We assumed that super-selective catheterization is essential to implement safe and effective PAE, and that regular catheter length could be a limitation in tall patients. Thus, height ≤ 172 cm might be a safe selection criterion for PAE via TRA. The purpose of this study was to evaluate the safety and feasibility of PAE via TRA compared with TFA.

MATERIALS AND METHODS

Patients

The Institutional Review Board of our institute approved this study and waived the need for informed consent owing to its retrospective nature (IRB No. OC21RISI0117). A total of 53 consecutive men with LUTS were treated with PAE via TRA or TFA between September 2018 and September 2021. All patients were unfit for surgery because of combined morbidity or unwillingness to undergo surgery. The medical records and images of the patients were reviewed. From September 2018 to November 2019, before adopting TRA, 14 patients were treated with TFA. After this period, patients with a height of ≤ 172 cm and patent carpal arch circulation were treated via TRA, and the remaining patients were treated with TFA. Carpal arch patency was screened using the Allen test (≤ 5 seconds). The Barbeau test was used in patients with prolonged Allen test results [4]. In patients with a small radial artery (< 2 mm), the radial artery was accessed proximally than usual. The patient selection flow chart is presented in Figure 1. Preprocedural medical history, including medication history, acute or chronic urinary retention, height, weight, body mass index, comorbidity, prostate-specific antigen (PSA), and urinalysis, were evaluated. Preprocedural and postprocedural studies including the International Prostate Symptom Score (IPSS), quality of life (QoL) score, uroflowmetry, CT, and transrectal ultrasonography were reviewed. To evaluate the accessibility of the target arteries, pelvic CT with three-dimensional (3D) angiography was performed, including arterial and 80-second delayed phases with 100–120 mL contrast medium (Iomeron 350, Bracco) and reconstructed 1-mm and 5-mm thickness, respectively (Aquilion PRIME, 64 slices, Canon Medical systems). Acquisition parameters were as follows: 100 kVp; 262 mAs; matrix size, 512 x 512; collimation, 6.2 mm; slice thickness, 1.0 mm; and pitch, 0.810. Thin-section CT data were uploaded to an angiography machine before PAE to acquire 3D real-time navigation data (VesselNavigator; Philips). Two angiography machines with the same model (Allura Xper FD20, Philips) were used for PAE and assigned based on a daily schedule.

The patients were placed in a supine position with arms abducted and headed to the right side of the practitioner (Fig. 2). Urinary catheters were placed in all patients before the procedure to void the contrast medium and avoid voiding during the procedure. The catheters remained in place for 1 or 2 days to prevent acute urinary symptoms. Sedatives and analgesics were not routinely administered unless needed. Antibiotics (cefotetan) were administered on the day of the procedure and 1 day post procedure. To enhance embolization, 1 mL of vasodilating cocktail was administered through a microcatheter immediately before transcatheter embolization in November 2019.

Transradial Access

Local anesthesia (2% lidocaine) was delivered to the

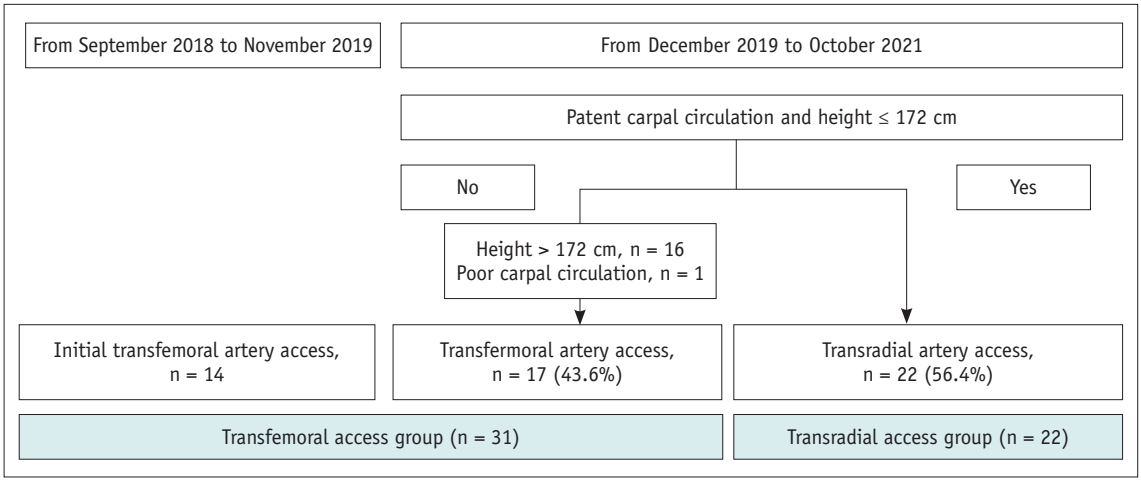

Fig. 1. Patient selection.

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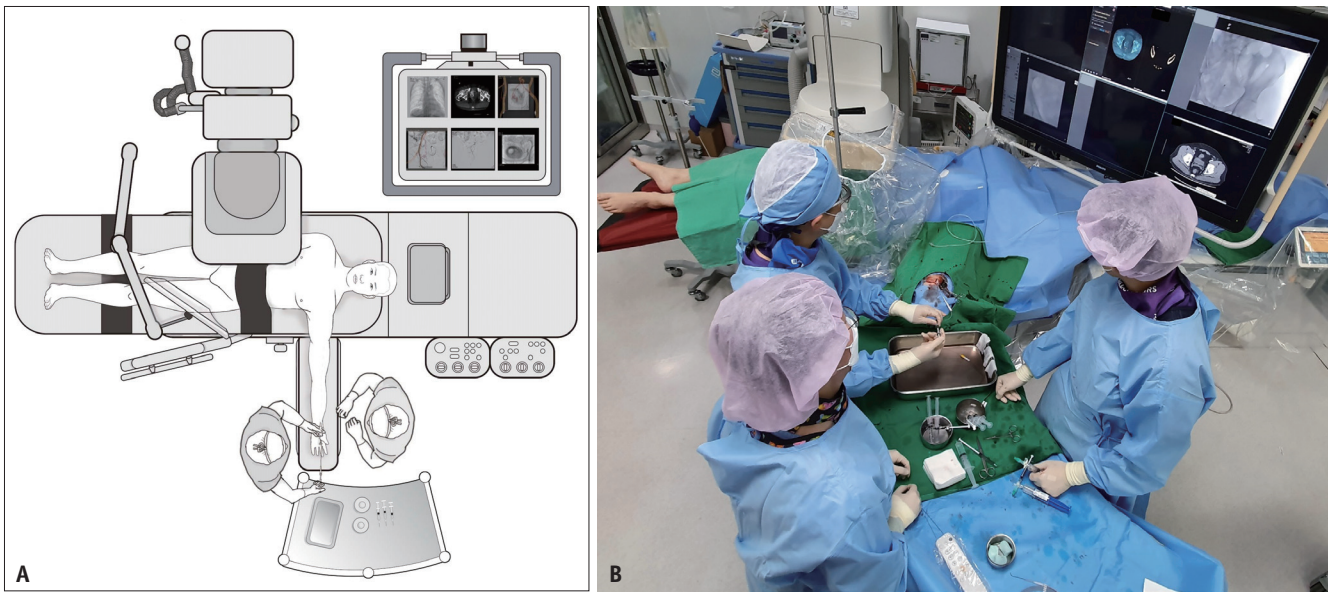

Fig. 2. Table setting of prostatic artery embolization via transradial access.
A. Schematic of patient position and angiography table setting. The operator can perform the procedure without motion limitations with the arm abducted. Radial access to the subclavian artery could be blindly navigated in most cases, but some patients required angiography with the arm abducted. A ceiling-mounted shield and movable lead table skirt between the patient and operators can protect operators from radiation, and the protectors can be removed during acquisition of cone-beam CT. **B.** A photograph showing actual setting of prostatic artery embolization via transradial artery access.

subcutaneous tissues around the left radial artery. This artery was then accessed with a microintroducer kit (Galt) equipped with a 21-G needle under ultrasonography guidance. A 7-cm, 5-French vascular sheath (Radiofocus, Terumo) was placed over the 0.025-inch guidewire. An antispasmatic cocktail (2 mg verapamil, 0.2 mg nitroglycerin, and 2000 IU heparin) was diluted to 20 mL and slowly reinjected [4]. An additional cocktail was injected every 1 hour through the sheath. Using standard angiography devices including a 125-cm, 5-Fr diagnostic catheter (Davis; Jungsung Medical) and a 180-cm, 0.035-inch guidewire (Radiofocus; Terumo), both internal iliac arteries (IIAs) were accessed under fluoroscopic and 3D real-time navigation guidance. The 3D-guiding system provided a real-time overlay of the 3D roadmap, which could save fluoroscopic time and contrast medium (Fig. 3A). The prostatic arteries were catheterized using a 150-cm microcatheter (1.7–1.9 Fr; Progreat Lambda, Terumo; Carnelian, Tokai Medical; and Pursue, Merit) and a 165-cm, 0.016-inch guidewire (Meister; Asahi Intecc). Hemostasis was achieved using a compression device (TR band; Terumo). Any conversion from TRA to TFA owing to catheterization difficulty or catheter length was recorded.

Transfemoral Access

After local anesthesia, the right common femoral artery was accessed with an 18-gauge needle (Angiocath; BD) under ultrasonography guidance, and a 10-cm, 5-Fr vascular sheath (Radiofocus; Terumo) was introduced over a 0.035-inch guidewire. Using a 0.035-inch guidewire (Radiofocus; Terumo) and a Roberts uterine (Jungsung Medical), Yashiro (Terumo), or Cobra catheter (Jungsung Medical), the left IIA was catheterized. The right IIA was catheterized using a Waltman loop or by direct selection. Hemostasis was achieved by closing the devices (Perclose, Abbott, or Mynx control, Cordis).

Prostatic Artery Embolization

All PAE procedures were performed by three dedicated interventional radiologists at a single institution (3, 4, and 7 years of experience at a single institution). After the IIA was selected, a 5-Fr catheter was advanced just above the pudendal artery or the anterior division of the IIA. Subsequently, the microcatheter was advanced into the prostatic artery. Selective digital subtraction arteriography of the IIA was performed, as necessary. Cone-beam CT images with contrast enhancement were obtained to confirm catheterization of the prostatic arteries before embolization (Fig. 3B, contrast medium: 2–3 mL of total

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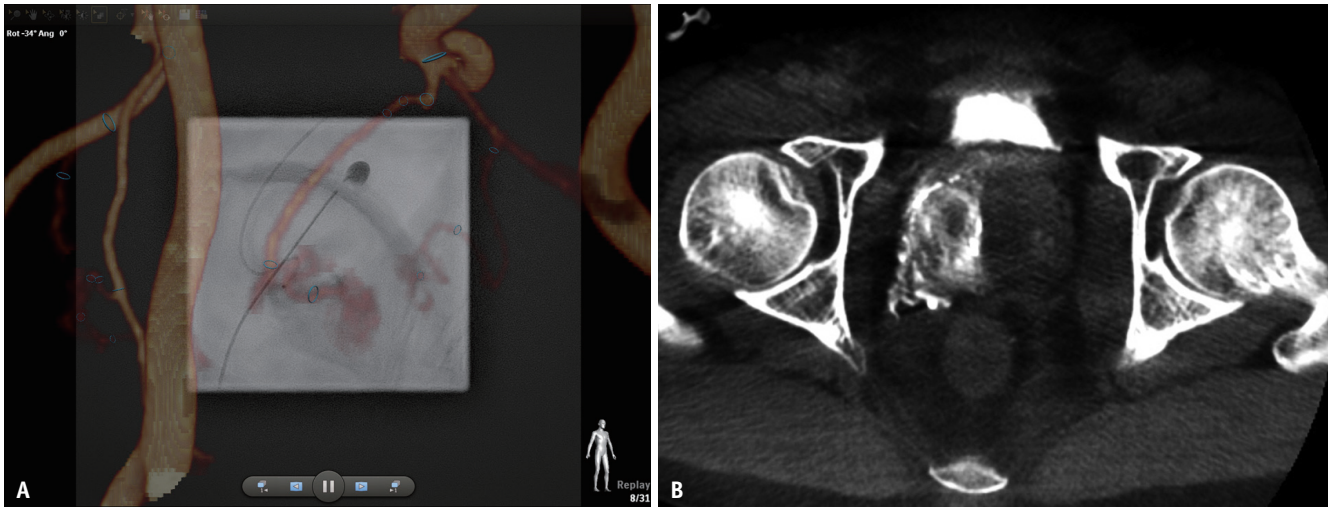

Fig. 3. A representative case of prostatic artery embolization via transradial access.
A. Captured image of real-time three-dimensional guidance showing the best angle for selection of the prostatic artery. A 68-year-old male with lower urinary tract symptoms who presented for prostatic artery embolization. Predesignated markers (blue rings) indicate the course of the prostatic artery even with indescribable small arteries. Proper selection of the target artery can be identified by changing the detector angle even without the use of contrast medium. **B.** Cone-beam CT with contrast enhancement showing successful cannulation of the prostatic artery. This is useful for the identification of a dangerous connection between the prostatic artery and a non-target organ. After prostatic artery embolization, his lower urinary tract symptoms improved (quality of life: from 5 to 1, international prostatic symptom score from 19 to 9, peak urinary flow velocity: from 3 to 7.6 mL/sec).

amount, 0.2–0.3 mL/sec of injection rate during 4 seconds delay and 8 seconds acquisition; Visipaque, GE). If there was no connection to the rectum or penis, prostatic arteries were embolized using 300–500 μm tris-acryl gelatin particles (Embosphere; Merit Medical) diluted in a 20-mL mixture of contrast media and normal saline at a ratio of 1:1. The PErFecTED technique has been used in eligible patients [8]. To prevent non-target embolization, hazardous connections were avoided in a superselective manner or, if inevitable, non-target arteries were embolized with microcoils (Concerto; Medtronics) [9].

Outcome Definitions

Technical success was defined as bilateral embolization of the prostatic artery. Clinical success was defined as a 15-point improvement in IPSS and/or a 25% decrease from baseline, improved QoL score (< 3 points or decreased by 1 point from baseline), improved peak urinary flow (7 mL/s or > 2.5 mL), and/or medical therapy no longer being necessary [1,10]. The total procedure time was defined as the interval from time-out to access site hemostasis. Adverse events (AE) were evaluated in accordance with the modified Clavien-Dindo classification [11,12]. Access-site complications included puncture-site pseudoaneurysm, infection, or hematoma.

Statistical Analysis

Normality of continuous variables was evaluated using the Shapiro-Wilk test. Missing data on fluoroscopic time and radiation dose were created by multivariate imputation via chained equations (MICE, cart method) using R software (R Foundation). An independent sample *t* test or Mann-Whitney test was used to compare the TRA and TFA groups in terms of total procedure time, fluoroscopic time, total dose-area product (DAP), and air kerma. The Wilcoxon signed-rank test was used to compare the prostate volume, uroflowmetry results, and IPSS. Medcalc ver. 20.011 (MedCalc Software bv) was used for the analyses. Statistical significance was set at $p \leq 0.05$.

RESULTS

All the 53 patients had LUTS. Two patients were diagnosed with prostate cancer at the time of PAE. Cancer in these patients was at the early localized state (stage < II), and LUTS were primarily due to prostatic enlargement. One patient had to undergo total prostatectomy for prostatic cancer diagnosed 7 months post-procedure. Hematuria was combined in seven patients, with five patients improving post-procedure, and two patients having persistent microscopic hematuria. TRA was attempted in 22 patients with positive Allen test results (≤ 5 seconds), and bilateral

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embolization, defined as technical success, was achieved in 21 patients (95%). TFA was attempted in 31 patients, and bilateral embolization, defined as the technical success, was achieved in 30 patients (97%). The initial 14 patients, 16 patients with height > 172 cm, and one patient with poor carpal circulation (Allen test of 9 seconds and Barbeau D type) received PAE via TFA. All TRA and TFA patients received at least one-side PAE. No conversion from TRA to TFA was necessary because of catheterization difficulties or catheter length.

Missing data of five patients regarding fluoroscopic time, total DAP, and air kerma were imputed using the MICE method. The total procedural and fluoroscopic times were not significantly different between the groups (p = 0.570 and p = 0.671, respectively). DAP and air kerma were not significantly different (p = 0.678 and p = 0.551, respectively). The patient characteristics and group results are presented in Table 1. The prostate volume in both groups decreased significantly after PAE (TRA, 22%; TFA, 43%; p = 0.043 and p = 0.003, respectively). The IPSS and QoL scores significantly improved after PAE (IPSS: p = 0.003 for both groups; QoL: p = 0.033 for TRA, p = 0.005 for TFA). Peak urinary flow rates were significantly higher in the TRA group (p = 0.002). In the TFA group, the peak urinary flow rate improved, although this change was not statistically significant (p = 0.173). Post-void residual volume significantly decreased in both groups (TRA, p = 0.011; TFA, p = 0.007), as well as PSA (TRA, p = 0.006; TFA, p = 0.003). The overall clinical success rates were 85% in TRA patients and 89% in TFA patients who were followed up (> 2 weeks post-PAE, median 3 months). The comparative clinical results are presented in Table 2.

Table 1. Baseline Characteristics and Procedural Details for Patients Who Underwent PAE via Transfemoral or Transradial Access

Variable	Transfemoral Access (n = 31)	Transradial Access (n = 22)	*P*
Patients			
Age, year	70.4 ± 8.7	69.6 ± 9.6	0.535
Height, cm	167.4 ± 6.5	163.7 ± 5.5	0.036
Weight, kg	69.6 ± 12.3	69.2 ± 12.4	0.920
Body mass index, kg/m^2	24.7 ± 3.5	25.8 ± 4.0	0.317
Prostate size on CT, mL	90 (40–302)	64 (36–239)	0.003
Indication for PAE			
LUTS	31 (100)	22 (100)	
Urinary retention	16 (53)	14 (64)	
Prostate cancer	2 (7)	0 (0)	
Procedure			
Total procedure time, minutes	94 (39–195)	80 (37–191)	0.570
Fluoroscopic time, minutes	41 (15–71)	37 (15–96)	0.671
Dose-area product, Gycm^2	84 (34–255)	95 (44–255)	0.678
Air kerma, mGy	634 (217–1594)	609 (236–1584)	0.551
Technical success	30 (97)	21 (95)	> 0.999

Data are presented as mean ± standard deviation, median (range), or patient number (%). LUTS = lower urinary tract symptoms, PAE = prostatic artery embolization

Table 2. Comparative Clinical Outcomes of Patients at Median 3-Month Follow-Up after Prostatic Artery Embolization via Transfemoral or Transradial Artery Access

Parameters	Transfemoral Artery Access			Transradial Artery Access		
	Before	After	*P*	Before	After	*P*
Prostate volume, mL	104 (40–302)	59 (28–264)	0.003	77 (65–159)	60 (56–109)	0.043
IPSS	19 (8–28)	5 (3–13)	0.003	17 (2–35)	7 (2–26)	0.003
QoL score	4 (0–6)	1 (0–2)	0.005	3.5 (1–6)	1 (0–5)	0.033
Qmax, mL/sec	8.2 (3.8–21.6)	10.0 (3.7–44.8)	0.173	5.6 (0.6–12.5)	11.7 (2.5–25.3)	0.002
PVR, mL	81 (14–233)	45 (0–184)	0.007	90 (12–495)	30 (0–259)	0.011
PSA, ng/mL	3.3 (0.2–63.8)	2.0 (0.2–14.0)	0.003	5.6 (1.2–38.1)	1.3 (0.3–5.0)	0.006

Data are presented as median (range). IPSS = International Prostate Symptom Score, PSA = prostate specific antigen, PVR = post-void residual volume, Qmax = peak urinary flow rate, QoL = quality of life

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No serious AE (> grade II) occurred in any of the patients. The most common AE was nausea (n = 5), followed by penile pain (n = 4), pelvic pain (n = 4), and urinary catheter discomfort (n = 4). Other AEs included headache (n = 3), dizziness (n = 3), residual urine sensation (n = 2), dysuria (n = 2), constipation (n = 2), hematuria (n = 2), weak ejaculation (n = 1), anal pain (n = 1), frequency (n = 1), fatigue (n = 1), insomnia (n = 1), diarrhea (n = 1), and delirium (n = 1). All AEs were grade I or II, which improved with conservative treatment. No radial artery-associated AEs were observed, except in one patient who complained of TRA-associated wrist pain with no hematoma or infection. However, this improved after 2 days of conservative treatment. No femoral artery-associated AEs were observed.

DISCUSSION

This retrospective study demonstrated that PAE can be performed safely by TRA in lieu of TFA using common devices in angiography suites with patient selection criteria of height and carpal circulation. Furthermore, parameters involving technical and clinical outcomes showed no significant differences between the TRA and TFA access groups.

Previous studies have demonstrated the advantages of TRA in terms of patient comfort and safety [6,13,14]. Many interventions can be safely performed via TRA, even in coagulopathies [5]. Additionally, patients who undergo endovascular aneurysm repair can be treated more effectively with TRA. Patients treated with TRA achieved earlier ambulation and hospital discharge. Despite these benefits, many operators hesitate to perform TRA because of their unfamiliarity and concerns about needing lengthier equipment [15]. In this study, we used regular angiography devices, such as 5-Fr 125-cm diagnostic catheters, 1.9-Fr 150-cm microcatheters, and 0.016-inch 165-cm microwires. Superselective and PErFecTED techniques with standard devices have height limitations because of the limited catheter length [7]. Although Bhatia et al. [16] performed PAE via TRA without height limitations and found comparable results, we found it challenging to select a long collateral artery. A height limitation of 172 cm or less was determined by measuring the length between the sheath valve and catheter end during the initial TRA experience. This could be a conservative threshold; however, lack of catheter length during the procedure and transition from TRA to TFA would be time-consuming and could cause AEs.

In conventional TRA, left radial access is preferred to reduce the angle between the brachiocephalic artery and aorta, and the patient heads are positioned to the left of the operator. In this study, TRA was performed in patient heads positioned to the right of the operator using left radial access, which is the opposite of the conventional setting. The conventional approach could cause back pain to the operator because the procedures were performed across the patient's body. Furthermore, the prostate and wrist are in the same plane during the procedure with the arm adducted, the operator can be exposed to radiation, and the arm can cause artifacts during cone-beam CT.

The limitations of this study include selection bias due to its retrospective nature and incomplete follow-up data. However, the clinical outcomes were similar to those reported in previous studies. In our study, TRA was not attempted in patients taller than 172 cm; thus, the disadvantages of TRA in taller patients remain unclear. Contemporary and commercially available thin microcatheters (≤ 2.0 Fr) are mostly 150-cm long. Considering the typically small diameter of the prostatic artery, the use of thin microcatheters may be beneficial. With height-limited patient selection, we successfully performed PAE without conversion from TRA to TFA, using regular devices.

In conclusion, PAE via TRA is a safe and feasible method comparable to conventional TFA. It can be safely implemented in patients with patent carpal circulations and adequate height.

Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

Conflicts of Interest

Dong Jae Shim who is on the editorial board of the *Korean Journal of Radiology* was not involved in the editorial evaluation or decision to publish this article. All remaining authors have declared no conflicts of interest.

Author Contributions

Conceptualization: Dong Jae Shim. Data curation: Ryun Gil, Dong Hwan Lee, Jung Jun Kim. Formal analysis: Dong Jae Shim. Investigation: Doyoung Kim. Methodology: Dong Jae Shim. Project administration: Jung Whee Lee. Resources: Dong Jae Shim. Software: Dong Jae Shim. Supervision: Dong Jae Shim. Validation: Dong Jae Shim. Visualization: Dong

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