Early Results of Unilateral Prostatic Artery Embolization as a Focal Therapy in Patients with Prostate Cancer under Active Surveillance: Cancer Prostate Embolisation, a Pilot Study

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ABSTRACT

Purpose: To evaluate the feasibility of prostatic artery embolization in patients with low-risk prostate cancer (PC) under active surveillance (AS).

Methods: This monocentric prospective pilot study, running from June 2018 to June 2019, included 10 patients with low-risk PC under AS, median age 72 years (range, 62–77 years), with a unilateral focal lesion visible on magnetic resonance (MR) imaging, with Prostate Imaging Reporting and Data System v2 score ≥3/5 confirmed by multiparametric MR imaging-targeted biopsy and Gleason score 6. The patients underwent unilateral prostatic artery embolization with 300–500 μm Embospheres in the affected prostatic lobe. The primary endpoint was technical feasibility (prostate and no off-target ischemia in the imaging). The secondary endpoints included safety, negative biopsies/MR imaging response/functional outcomes at 6 months, and oncologic efficacy at 1 year.

Results: Embolization was successfully achieved in all patients; prostate ischemia was confirmed on multiparametric MR imaging, and no off-target ischemia was reported. No major complications were reported. Four patients (40%) presented with both negative targeted and systematic biopsies at 6 months. No lesions were seen on the MR imaging in 30% of patients. The mean International Prostate Symptom Score and International Index of Erectile Function score were 7 and 19 and 5 and 20 at baseline and 6 months, respectively, with no significant difference. Nine patients (90%) were still under AS at 1 year. One patient (10%) had PC progression outside the target lesion and was switched over to curative radiotherapy.

Conclusions: Prostatic artery embolization is feasible and appears safe for prostate cancer patients under AS, with no impact on erectile function or continence status. These results justify the pursuit of further studies.

ABBREVIATIONS

AS = Active surveillance, PAE = Prostatic artery embolization, PC = Prostate cancer, PIRADS = Prostate Imaging Reporting and Data System, PSA = Prostate-specific antigen, QoL = Quality of life

Prostate cancer (PC) is the second most common cancer in men worldwide, with 29.3 new cases reported per 100,000 men in 2018 (1). The incidence has increased due to greater life expectancy and better detection of the asymptomatic localized low-risk PC with the widespread use of prostate-specific antigen (PSA) screening. Management of very

low- or low-risk patients with a life expectancy of >10 years is based on active surveillance (AS) (2). Eligibility for AS varies according to the recommendations and includes a PSA level of <10 ng/mL, stage T1 or T2, and a Gleason score of 6 or 7 (3 + 4) (International Society of Urological Pathology score 1 or 2) on up to 2 positive biopsy cores <3 mm (2,3). AS aims to reduce the overtreatment and postpone the curative radical treatments (radiotherapy and prostatectomy), which induce side-effects on sexual quality of life (QoL) and urinary continence, with no major improvement in the overall survival (4–6). A recent study (7) randomized 1,643 patients between radiotherapy, surgery, and AS. The cancer-related mortality rate at 10 years was not significantly different between the groups. However, disease progression, including the occurrence of metastasis, was significantly higher in patients under AS.

The rate of patients who switched over to radical treatment due to disease progression, grade reclassification, or patient decision greatly varied from 37% to 73% at 10 years (3,7,8). Focal therapies have thus emerged as an alternative to radical curative treatment (9,10), including thermal therapies such as cryotherapy (11) and high-frequency focused ultrasound (12), or a new vascular-targeted photodynamic therapy called TOOKAD, which induces local thrombosis within the blood vessels, leading to ischemia (13,14). A phase III randomized trial compared TOOKAD with standard AS in low-risk patients and showed a longer time to progression and a lower disease progression rate with TOOKAD. More patients presented negative biopsy results at 24 months after treatment (13). Locoregional ischemia-based therapies have thus demonstrated their efficiency in PC treatment.

Prostatic artery embolization (PAE) is used in the treatment of lower urinary tract symptoms related to benign prostatic hyperplasia treatment and has been shown to be safe and efficient (15–17). Randomized trials comparing PAE with standard treatment have reported few adverse effects, with the preservation of erectile and urinary functions (15). PAE was recently used in PC patients in 2 studies, with no significant results (18,19). The patients included had an advanced-stage PC (T2c/T3) and were undergoing treatment or were in a palliative situation. This pilot study evaluated the feasibility, safety, and efficacy of unilateral PAE in patients under AS with low-risk PC presenting a focal lesion visible on MR imaging with Prostate Imaging Reporting and Data System v2 (PIRADS) score ≥3/5, confirmed by multiparametric MR imaging-targeted biopsy.

MATERIALS AND METHODS

Study Design and Objectives

The primary objective of this prospective monocentric pilot study was to evaluate the feasibility of unilateral PAE in patients with localized low-risk PC under AS. The secondary objectives were to evaluate the safety, response of the target lesion upon biopsy and multiparametric MR imaging, PSA level, functional outcomes, and short-term oncologic

Table 1. Patients' Characteristics at Baseline

Patients' characteristics	N = 10
Age, median (range)	72 (62–77)
BMI, median (range)	24.5 (21.3–35)
Ethnic origin, n (%)	
Caucasian	9 (90)
North African	1 (10)
MR imaging prostate volume, cm³, median (range)	67.5 (31–111)
PSA level, ng/mL, median (range)	6.22 (3.28–10.14)
Rectal examination, n (%)	
Soft	5 (50)
Firm	2 (20)
Nodular	3 (30)
T clinical stage, n (%)	
T1c	5 (50)
T2a	5 (50)
Localization, n (%)	
Side	
Left	3 (30)
Right	7 (70)
Anatomical region	
Apex	5 (50)
Medial	3 (30)
Basal	2 (20)
Anterior	5 (50)*
Posterior	6 (60)*
Peripheral zone	6 (60)
Transitional zone	4 (40)
MR imaging focal lesion size, mm, median (range)	10 (7–16)
PIRADS score, n (%)	
3	1 (10)
4	9 (90)
5	0
Number of positive biopsies, n (%)	
1	6 (60)
2	2 (20)
3	2 (20)†
Gleason score, n (%)	
6	10 (100)
7 (3 + 4)	0 (0)

BMI = body mass index; PIRADS = Prostate Imaging Reporting and Data System; PSA = prostate specific antigen.
*Patient 2: focal lesion both posterior and anterior.
†Patients 4 and 7: Two positive biopsies in the target lesion and 1 next to it, in systematic biopsies.

efficacy, that is, switching over to radical treatment. All patients signed an informed consent and the study was approved by the ethical review board. The study was performed according to Good Clinical Practice requirements and the Helsinki Declaration and registered on ClinicalTrials.gov (NCT03407963). After the inclusion of 5 patients, an independent surveillance committee was formed to evaluate the safety before allowing the study to continue.

Table 2. Technical and Imaging Data

Patient	Embolized prostatic artery number, side, origin	Volume of microspheres injected (mL)	Procedure duration (min)	Total Kerma Area Product (mGy.cm^2)
1	1, right, superior vesical artery	3	35	184,329
2	**1, right, rectal artery**	**3**	**85**	**138,930**
3	1, left, superior vesical artery	5	31	58,316
4	1, left, superior vesical artery	4.5	51	82,396
5	2, right, obturator artery ×2	4 (2 + 2)	55	120,937
6	1, right, superior vesical artery	3	50	39,666
7	1, right, gluteal artery	4	69	69,743
8	**1, right, obturator artery**	**4**	**47**	**139,687**
9	**1, left, superior vesical artery**	**3.5**	**46**	**71,089**
10	**2, right, pudendal and obturator arteries**	**7 (3 + 4)**	**125**	**211,118**

Note–**Bold** indicates no positive biopsy reported in the targeted or systemic biopsies at 6 months.
Embolization was performed with a mixture of 12 mL of contrast media, 8 mL of saline, and 2 mL of microparticles (Embosphere, 300–500μm, Merit Medical System, South Jordan, Utah).

Study Population

Patients with unilateral low-risk PC (d'Amico classification) at the clinical stage <T2b were included. The main inclusion criteria were age 18–80 years, life expectancy >10 years, focal lesion on MR imaging, PIRADS v2 score ≥3/5, positive multiparametric MR imaging target lesion, PSA level <10 ng/mL (or ≥10 ng/mL in the event of a large prostate volume), presence of unilateral positive MR imaging-targeted biopsies, and Gleason score ≤6 (International Society of Urological Pathology 1), with <3 positive biopsies and <50% of positive biopsy length. The main criteria for non-inclusion included the patient's ineligibility or refusal to undergo AS, contraindication for MR imaging (incompatible pacemaker, claustrophobia, hip prosthesis, or metallic implanted device) or administration of the study products, a tumor on both lobes, or a hemostasis disorder.

From June 2018 to June 2019, 10 patients with a median age of 72 years (range, 62–77 years) were included in the study. Baseline patient and tumor characteristics of prostate biopsies are reported in Table 1.

Technical Procedures

Biopsy. Biopsies were performed at baseline and 6 months after PAE by an experienced operator (A.H.), including 1–3 multiparametric MR imaging-targeted biopsies in the target lesion region under real-time transrectal ultrasonographic guidance and visual real-time matching between MR imaging target lesions and prostate image (Toshiba Aplio 500 smart fusion, Tokyo, Japan) and 9–12 transrectal ultrasonographic standard systematic biopsies (20).

PAE. PAE was performed by an interventional radiologist (J.F., with 10 years of experience and >30 cases of PAE performed) under local anesthesia. Both digital subtraction angiography and cone-beam computed tomography (CT) were performed using a pump injection to evaluate the iliac vessels and identify the prostatic arteries. Prior to PAE, each artery was controlled by cone-beam CT to assess which part of the prostate was vascularized and to avoid off-target ischemia. Unilateral embolization was performed using Trisacryl microspheres (Embosphere, 300–500μm, Merit Medical System, South Jordan, Utah), until the prostatic artery was completely occluded. The volume of microspheres injected was recorded and compared with the embolized prostate volume. PAE was performed on an ALLURA Xper FD20 (Philips Healthcare, Best, the Netherlands) and the radiation dose, that is, total kerma-area product was collected for all patients.

A follow-up angiography was performed to check for any prostatic lobe blood supply after PAE. The patients were discharged on the following day.

Imaging. Multiparametric MR imaging was performed at baseline, 2 weeks, and 6 months after PAE, using a 3.0-T scanner (MAGNETOM Skyra, Siemens, Erlangen, Germany) with a pelvic phased-array coil. 3DT2-weighted, diffusion-weighted, and dynamic contrast-enhanced imaging sequences were acquired according to the European guidelines (21).

Endpoints and Assessments. The primary endpoint was technical feasibility, defined as blood flow arrest assessed by angiography, ischemia of the prostatic lobe on imaging at 2 weeks, and the absence of specific risks, especially off-target ischemia (penis, bladder, and rectum) assessed at day 1, day 5 (follow-up phone call), and day 15 (clinical evaluation at the time of the MR imaging) and at 1, 3, and 6 months. The secondary endpoints were safety (Clavien-Dindo classification) and negative-targeted and systematic biopsies at 6 months; multiparametric MR imaging response of the target lesion at 6 months (PIRADS v2 score); functional outcomes evaluated using validated questionnaires/tests at baseline, 1, 3, and 6 months after PAE: urinary-specific QoL (International Prostate Symptom
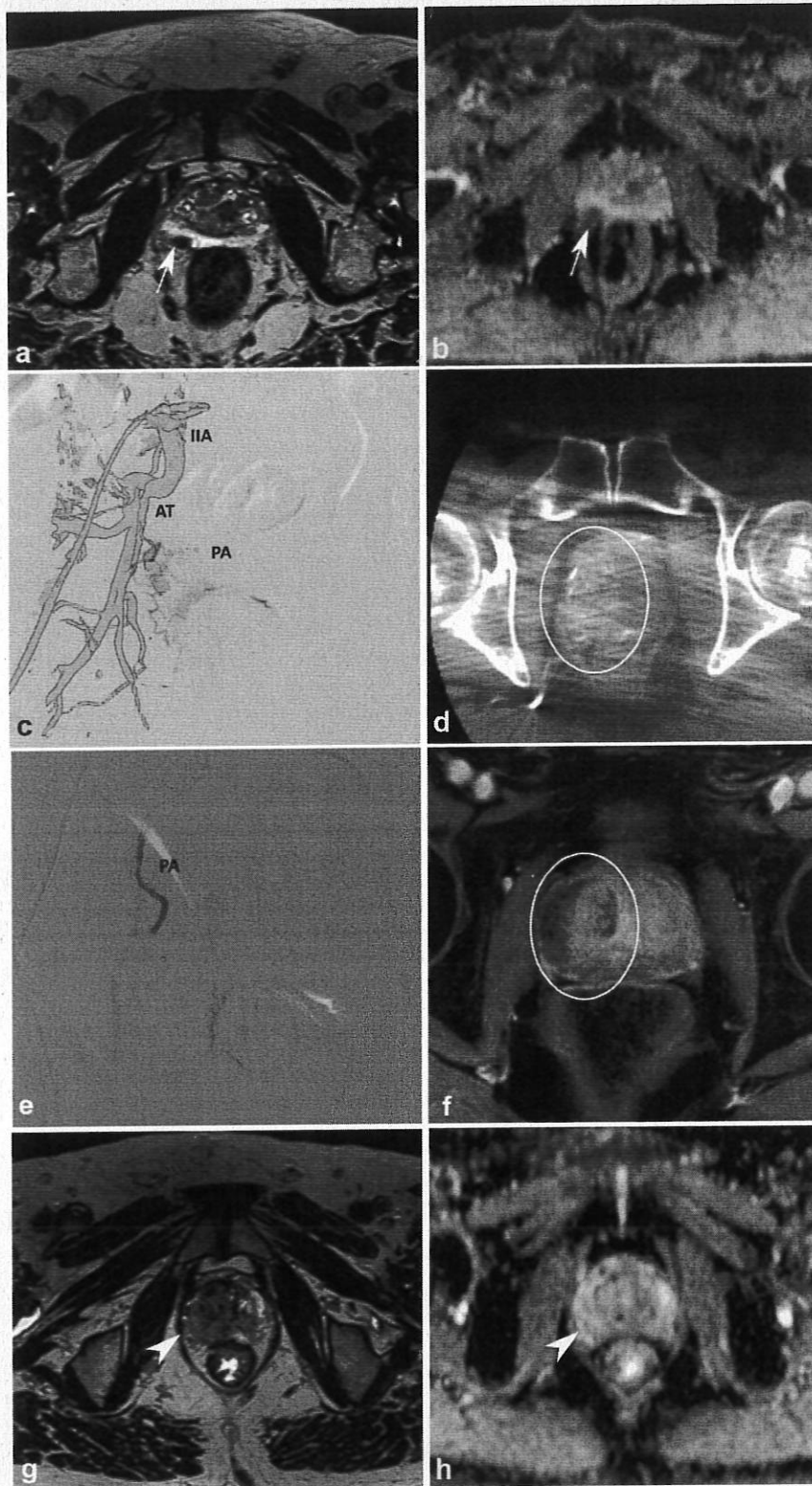
Figure 1. Feasibility of prostatic artery embolization: Multiparametric MR imaging of patient 6 with the target lesion (white arrow) visible in (a) 3DT2-weighted imaging and (b) apparent diffusion coefficient (ADC) map as a well circumscribed hypointensity in the right peripheral zone, measuring 10 mm. Digital subtraction angiography with injection in the internal iliac artery (c) showed the right prostatic artery arising from the anterior trunk. The cone-beam CT angiography performed in the prostatic artery (d) confirmed the tumor-feeding artery, with the vascularization of the right prostatic lobe (white circle). Successful embolization was defined by the complete stasis of flow in the prostatic artery in the post embolization angiography (e). Dynamic contrast-enhanced MR imaging at 15 days (f) confirmed partial and heterogeneous ischemia of the right prostatic lobe (white circle), visible in 3DT2-weighted imaging (g) as a diffuse unilateral hypointensity (white arrow) and a heterogeneous iso intensity on the ADC map (h).

Score), incontinence (24-hour Pad test in the event of urinary leakage), erectile dysfunction (International Index of Erectile Function, IIEF-6) and QoL (EQ-5D); early oncologic efficacy at 1 year, that is, the rate of patients switching over to radical treatment (with the decision being made at a multidisciplinary meeting after multiparametric MR imaging, biopsies, and biology results).

Statistical considerations. Considering the study design and lack of literature data, no formal calculation was made to determine the number of required subjects but 10 patients were included. Quantitative variables are presented using medians and ranges. Qualitative variables are presented with numbers and percentages. Values were compared using Mann-Whitney U tests.

RESULTS

Feasibility and Safety
Embolization was successfully achieved in all patients. The median embolization procedure time was 50 minutes (range, 31–125 minutes), and the median radiation dose received was 101,666 $mGy.cm^2$ (range, 39,666–211,118 $mGy.cm^2$) (Table 2). The artery selected for embolization was confirmed by cone-beam CT (Fig 1a–h). Prostate ischemia was confirmed by multiparametric MR imaging at 2 weeks. No off-target ischemia was reported, and no target lesions were seen in the angiography.

No major complications were reported. Minor complications (Clavien-Dindo I or II) occurred in 3 patients (30%). Patient 3 reported a Grade II urinary infection on day 3, which was successfully treated with ofloxacine (200 mg) twice a day for 10 days. Patient 5 had Grade I prostatic pain just after embolization, which resolved within 5 days following treatment with prednisolone (20 mg) combined with omeprazole (20 mg) once a day and paracetamol (1000 mg) 4 times a day. Patient 6 had Grade I superficial hematoma at the puncture site 2 days after embolization, with spontaneous resolution and no clinical consequences. All patients were discharged the day after embolization according to protocol requirements.

Biopsy and Imaging Results
At baseline, 8 patients (80%) reported 1 positive targeted biopsy, 2 patients (20%) reported 2 positive targeted biopsies, and 2 patients (20%) also reported 1 positive systematic biopsy (Table 3). Six months after PAE, 3 patients (30%) had targeted biopsies in the area where the tumor was previously located as no target lesion was visible on multiparametric MR imaging (Table 3 and Fig 2a–f). In these 3 patients (30%) with complete response on multiparametric MR imaging (no visible PIRADS v2 lesion, Table 4), 2 reported negative biopsies performed in the former target location. Overall, 4 patients (40%) reported both negative targeted and systematic biopsies. One patient's PC (10%) had progressed in the systematic

biopsy at 6 months (Gleason score 7, 3 + 4), outside the target lesion.

The size of the target lesion on multiparametric MR imaging was 10 mm (range, 7–16 mm) at baseline and was stable. Ischemia of the prostatic lobe was partial and heterogeneous, involving 20% (range, 10%–40%) of the tissue (Fig 2a–f and Table 4). Ischemia was visible at 2 weeks after PAE but not at 6 months.

PSA levels were similar before and after embolization. As expected, the prostatic volume decreased from 67.5 cm^3 (range, 31–111 cm^3) at baseline to 54.0 cm^3 (range, 37–95 cm^3) at 6 months ($P = .344$) (Table 4).

Functional Outcomes
Overall, the functional outcomes improved after PAE: no urinary incontinence was reported, and the patients showed better urinary status (International Prostate Symptom Score: 5 (range, 1–16) at baseline and 1 (range, 1–19) at 6 months) (Table 5). Moreover, no erectile dysfunction was reported after embolization.

Early Oncologic Efficacy
At 1 year, 9 patients (90%) were still under AS and the patient whose PC had progressed outside the target as per the systematic biopsy was reclassified and switched over to curative external beam radiotherapy.

DISCUSSION

The results show that therapeutic unilateral PAE in patients under AS for low-risk PC with a focal lesion visible on MR imaging with PIRADS ≥3/5 confirmed by a targeted multiparametric MR imaging biopsy is feasible and seems safe and promising. PAE is already used for the treatment of benign prostatic hyperplasia with good results in terms of safety and efficacy (16). PAE was performed in patients with low-risk PC under AS to postpone switching over to radical treatment and limit the side-effects on erectile and urinary functions.

It was decided to perform unilateral PAE for various reasons. First, the patients were addressed for unilateral PC and not for low urinary tract symptoms. Second, unilateral PAE represented a shorter procedure time with potentially fewer side effects. Third, it allowed us to study the locoregional effect of PAE in greater depth. The feasibility of unilateral PAE for these patients was demonstrated as partial prostatic ischemia was achieved for all of them. This non-invasive treatment was performed in a short time (median duration: 50 minutes), with discharge on the following day. If complete safety is confirmed, an ambulatory setting may be possible. The PAE procedure has advantages compared to other focal therapies developed as alternatives to radical treatment. Indeed, most other therapies published are costly, require specific logistics (dark room, etc), and adverse events such as erectile dysfunction and other complications

Table 3. Biopsy Results at Baseline and at 6 Months after Prostatic Artery Embolization

	Baseline					At 6 mo				
	Number of positive biopsies/number of biopsies performed		Max core length (mm)	Gleason score	PSA level (ng/mL)	Number of positive biopsies / number of biopsies performed		Max core length (mm)	Gleason score	PSA level (ng/mL)
	Targeted biopsies	Systematic biopsies				Targeted biopsies	Systematic biopsies			
Patient 1	1/1	1/11	5	6	3.3	1/2	1/10	3	6	2.9
Patient 2	**1/1**	**0/12**	**1**	**6**	**3.4**	**0/1***	**0/11**	**/**	**/**	**0.3**
Patient 3	1/1	0/11	1	6	7.1	1/2	1/10	4	7 (3+4)†	6.0
Patient 4	2/2	0/10	3	6	6.8	2/2	1/12	6	6	6.3
Patient 5	1/1	0/11	1	6	8.7	1/2	0/10	4	6	6.8
Patient 6	1/1	0/11	1.5	6	10.1	2/2*	0/10	5	6	5.1
Patient 7	2/2	1/12	8	6	8.5	1/3	0/9	1	6	7.6
Patient 8	**1/1**	**0/12**	**1**	**6**	**5.6**	**0/1***	**0/11**	**/**	**/**	**3.6**
Patient 9	**1/1**	**0/12**	**2**	**6**	**1.9**	**0/3**	**0/9**	**/**	**/**	**2.9**
Patient 10	**1/1**	**0/12**	**2**	**6**	**4.3**	**0/2**	**0/10**	**/**	**/**	**2.9**

Note–**Bold** indicates no positive biopsy reported in the targeted or systemic biopsies at 6 months.

PSA = prostate specific antigen.

*Patients 2, 6, and 8: no target lesion was visible on magnetic resonance imaging at 6 months; target biopsies were performed in the area where the tumor was previously located.

†Patient 3 progressed outside of target lesion.

related to off-target tissue ablation have been reported. Also, some prostate locations, such as the anterior sites or those close to the apex or urethra, are either inaccessible or too risky for other focal therapies (22). In this study, PAE was possible in many prostate locations as the procedure consisted of embolizing the whole prostate lobe with no off-target ischemia.

The safety in this study was as good as that for other studies on PAE for benign prostatic hyperplasia, which reported very few complications (23). The functional outcomes were good, with no incontinence or sexual dysfunction, in agreement with other reported results of PAE for benign prostatic hyperplasia (15,16). PAE may also have the potential benefit of relieving emotional stress in patients who are anxious about their untreated cancer. Two previous studies on PAE in PC showed significant complications with equivocal oncologic results. Mordarsini et al (19) reported Grade 3b partial bladder wall necrosis in 2 patients and infected lymphocele (Grade 3a), and Pisco et al (18) reported off-target necrosis (bladder wall). They also reported Grade 2 incontinence and sexual dysfunctions (18,19). They used smaller microspheres (100–300µm) which could induce higher morbidity (24). Also, Pisco et al (18) performed bilateral chemoembolization with docetaxel in advanced cancer patients, which may explain this higher toxicity. In this study, unilateral PAE was performed in patients with low-risk PC and limited symptoms at baseline (median International Prostate Symptom Score of 5). Overall, these results are encouraging as the purpose of AS is precisely to avoid or postpone the side-effects induced by radical treatments (25). It is thus essential that the new focal therapies, proposed as an alternative to AS, do not induce important side-effects.

Focal treatment during AS is debated (26); therefore, patient selection was an important issue in this study. Only patients under AS presenting consequent lesions visible on multiparametric MR imaging (median index lesion 10 mm, upper Gleason 3 + 3 score) confirmed by targeted biopsy were included. Very low-risk patients were not included (26). Indeed, the patients with lesions found on MR imaging have a poorer disease evolution and oncologic outcome, which justifies proposing focal therapy during AS (27). Targeted biopsies have been shown to lead to a better identification of patients under AS who can benefit from hemi-ablative focal therapies (28). Indeed, targeted biopsies enabled us to carefully select patients, thus avoiding misclassifications during systematic follow-up biopsies (29,30).

Although the recent literature has highlighted the crucial role of multiparametric MR imaging in AS follow-up (31), this study seems to report the limitations in the use of multiparametric MR imaging for these patients. Indeed, 4 patients had negative systematic, targeted biopsies and 2 of them had a visible target in the imaging. It seems that the response of multiparametric MR imaging may be delayed compared with the biopsy results. Moreover, 1 patient with a complete response on multiparametric MR imaging reported a positive biopsy in the former target location. This emphasizes the limitations of concordance between the PIRADS v2 classification and oncologic results (32). These results also suggest that both targeted and systematic biopsies are important; indeed, in the patient whose disease had progressed, this was detected with systematic biopsies and not with the targeted biopsy (33). However, it is possible that the lesion was missed by the systematic biopsies and that this patient may initially have been understaged.
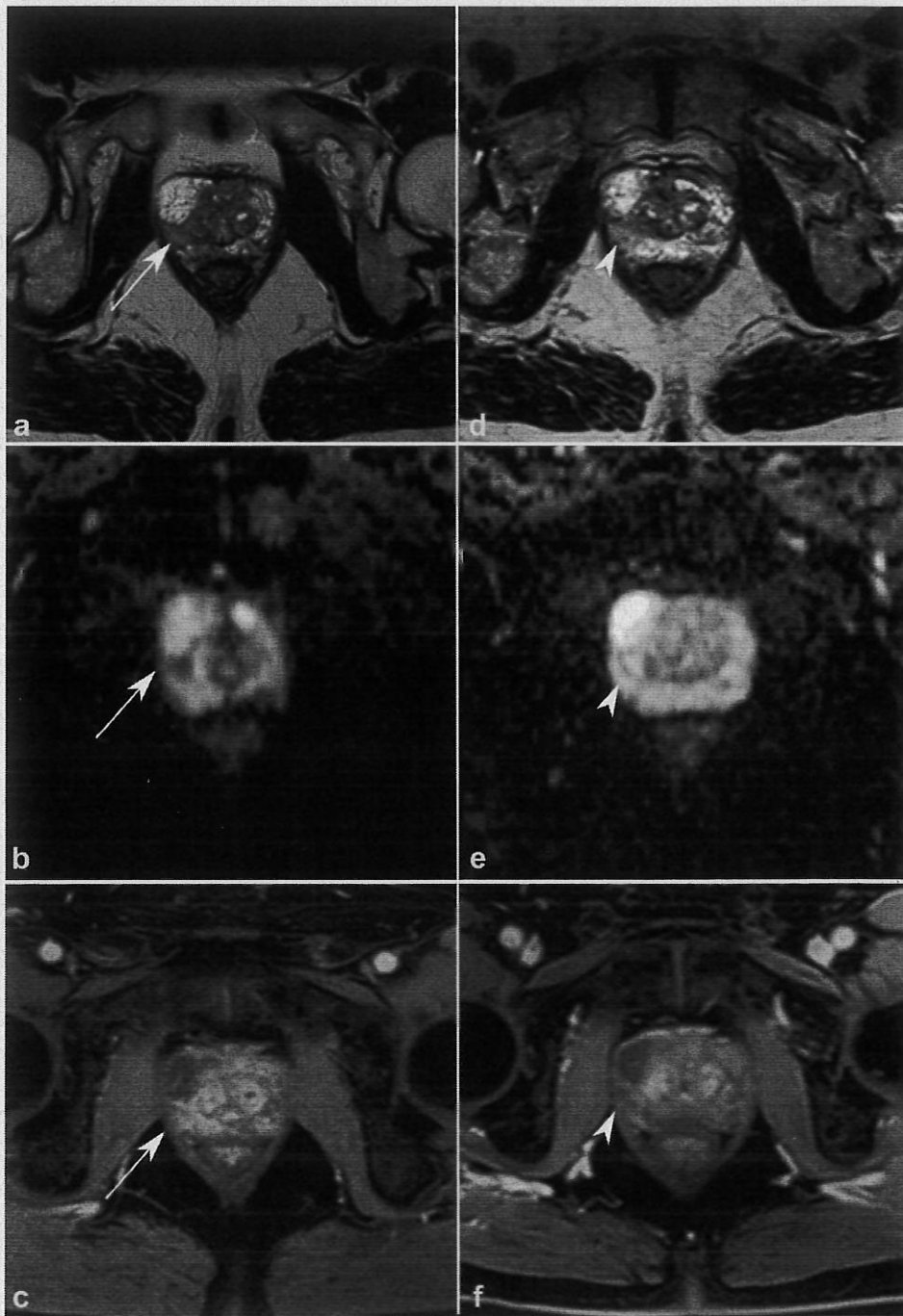
Figure 2. Efficacy of the procedure: At baseline, patient 2's multiparametric MR imaging showed a Prostate Imaging Reporting and Data System v2 4 target lesion of 9 mm in the right apex (white arrow) with a circumscribed homogenous T2 hyposignal (**a**), markedly hypointense on ADC map (**b**), with a positive focal enhancement in dynamic contrast-enhanced imaging (**c**). At 6 months following PAE, the circumscribed hyposignal was no longer visible in 3DT2-weighted multiparametric MR imaging (white arrow head, **d**), ADC map (**e**), and no focal enhancement was visible in dynamic contrast-enhanced imaging (**f**).

Azzouzi et al (13) reported similar results with TOO-KAD. They showed a 28% progression rate and switch to radical treatment and 49% negative biopsies at 2 years. It seems that the ischemic strategies do not achieve complete success rates, probably due to complex prostate vascularization, modified by the tumor (34). This may explain a heterogeneous distribution of the embolization microspheres and the partial, heterogeneous ischemia reported in the study. It is also possible that the number of microspheres injected plays a role in this random distribution of particles in the prostate volume. This raises the question of performing a bilateral embolization in refractory patients who may have developed contralateral arterial anastomoses. As PAE is a safe procedure, it may be possible to repeat PAE in the event of failure. Pisco et al (18) have shown the efficacy of such a strategy; among 3 patients who had biochemical

Table 4. MR Target at Baseline and at 2 Weeks and 6 Months after Prostatic Artery Embolization

	Baseline				At 2 wk				At 6 mo			
	PIRADS score*	Target lesion size, mm	Necrosis of the prostatic lobe, %	Prostate volume, cm³	PIRADS score*	Target lesion size, mm	Necrosis of the prostatic lobe, %	Prostate volume, cm³	PIRADS score*	Target lesion size, mm	Necrosis of the prostatic lobe, %	Prostate volume, cm³
Patient 1	4+	7	/	80	3+	7	30	83	3+	7	0	58
Patient 2	4+	9	/	31	4	9	10	30	CR	CR	0	37
Patient 3	4+	16	/	111	4+	18	20	121	3+	10	0	95
Patient 4	4+	10	/	75	4+	9	10	84	4+	10	0	70
Patient 5	4+	10	/	82	Ø assessable	Ø assessable	40	60	2+	5	0	64
Patient 6	4+	10	/	50	4+	7	40	46	CR	CR	0	38
Patient 7	4+	13	/	57	Ø assessable	13	20	61	4+	13	0	50
Patient 8	4+	11	/	72	3	Ø assessable	20	67	CR	CR	0	69
Patient 9	3	12	/	38	3	11	20	39	3	11	0	39
Patient 10	4+	10	/	63	3	7	40	53	3	10	0	45

Note–Ø assessable indicates target lesion not clearly identifiable because of ischemic remodeling.
CR = complete tumor response (no target lesion visible on magnetic resonance imaging); PIRADS = Prostate Imaging Reporting and Data System.
*Dynamic contrast enhancement is reported with a +.

Table 5. Functional Outcomes at Baseline and at 1, 3, and 6 Months after Prostatic Artery Embolization

	Baseline (N = 10)	1 month (N = 9*)	$P^\dagger$	3 mo (N = 9*)	$P^\dagger$	6 mo (N = 10)	$P^\dagger$
IPSS (/35), median (range)	5 (1–16)	2 (1–16)	.179	2 (1–9)	.197	1 (1–19)	.321
Urinary symptoms QoL (/6), median (range)	2 (0–4)	1 (0–4)	.189	1 (0–3)	.486	1 (0–3)	.365
IIEF-6 (/30), median (range)	24 (1–30)	24 (0–30)	.990	27 (1–30)	.528	27 (0–30)	.970
EQ-5D score (/100), median (range)	90 (40–100)	90 (50–95)	.855	90 (40–95)	.486	90 (40–100)	.786

IPSS = International Prostate Symptom Score; QoL = quality of life; IIEF-6 = International Index of Erectile Function; EQ-5D = European quality of life questionnaire.
*Data missing for 1 patient at 1 month (patient 5) and for 1 patient at 3 months (patient 7).
†compared to baseline.

failure of their first chemoembolization at 6 months and underwent a second procedure, 2 achieved biochemical success afterward.

Usual focal treatments are based on high focal energy deposits mainly using thermal ablation (high-frequency focused ultrasound or cryotherapy) (22). One reason why they cannot be used for all lesions may be the necessity to obtain clear margins, especially when close to the regions at risk. This study opens new perspectives with this new targeted vascular therapy. PAE is a different concept based on vascular territories, which may be used for patients with difficult-to-access lesions or regions at risk. It may also lead to the possibility of using chemotherapy-loaded particles that could be administered directly within the prostate, reducing the side effects of systemic chemotherapy. Moreover, potential radiotherapy treatment may still be possible after PAE in the event of disease progression; indeed, the 6-month MR images showed a complete regression of the ischemic effect of PAE.

This study has certain limitations, including those inherent to the pilot study design, as this was a mandatory stage before conducting further studies. The main limitations are the small number of patients included and the short follow-up (1 year) required due to the safety design. A 5-year follow-up would be more clinically meaningful for oncological results, especially regarding the switch to radical treatment. Another limitation is the absence of precise targeting of the lesion leading to the embolization of the entire prostatic lobe. Indeed, the lesions were not visible in the angiogram and this did not allow us to better target the embolization. Although there was a lack of a control group to assess the magnitude of treatment effect, these results are promising and warrant further investigations to determine the right number of microspheres to use and explore the long-term efficacy of PAE in these patients.

In conclusion, this pilot study showed that PAE is feasible and appears safe in patients with low-risk PC, with a visible lesion on MR imaging with PIRADS v2 ≥3/5 confirmed by multiparametric MR imaging-targeted biopsy under AS. This procedure offers the patients eligible for AS a "reinforced AS" as an alternative to focal therapy before eventually switching over to the radical treatment. Early results

with 40% of negative-targeted biopsies and 90% of patients still under AS at 1 year are encouraging and justify the pursuit of further studies. Randomized multicentric studies with the proportion of patients switching over to radical treatment as an endpoint would help to confirm the interest of this promising procedure.

ACKNOWLEDGMENTS

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