Cardiovasc Intervent Radiol (2014) 37:1602–1605
DOI 10.1007/s00270-014-0908-z

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TECHNICAL NOTE

The "PErFecTED Technique": Proximal Embolization First, Then Embolize Distal for Benign Prostatic Hyperplasia

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Received: 10 March 2014 / Accepted: 13 April 2014 / Published online: 19 June 2014

Abstract Prostatic artery embolization requires a refined technique to achieve good imaging and clinical success. The PErFecTED (Proximal Embolization First, Then Embolize Distal) technique has produced greater prostate ischemia and infarction than previously described methods with clinical improvement of lower urinary symptoms and lower recurrence rates. The microcatheter should cross any collateral branch to the bladder, rectum, corpus cavernosum, gonad, or penis and be placed distally into the prostatic artery before its branching to the central gland and peripheral zone. This technique allows better distribution of embolic material in the intraprostatic arteries and reduces risk of spasm or thrombus. Because benign prostatic hyperplasia develops primarily in the periurethral region of the prostate, the urethral group of arteries should be embolized first. Subsequent distal investigation and embolization completes occlusion and stasis of blood flow to the prostatic parenchyma. Since we added the second step to the PErFecTED technique, we have observed infarcts in all patients submitted to prostatic artery embolization.

Keywords Arterial intervention · Embolization · Embolotherapy · Prostate

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Introduction

Prostatic artery embolization (PAE) is an important alternative treatment for patients with lower urinary tract symptoms due to benign prostatic hyperplasia. A refined embolization technique is crucial for imaging and clinical success. Recently, we published our original techniques for performing PAE [1–3]. With over 5 years' follow-up, we have amassed significant clinical and technical experience, and we think we should share these technical improvements with others.

Magnetic resonance imaging (MRI) with contrast medium is crucial. MRI provides information about bladder thickness, diverticula, tumors and stones, and prostate anatomy, including asymmetry, median lobe size with intravesical protrusion, nodules, vascularization, size and characteristics of peripheral zone and central gland, pelvic lymph nodes, and incidental neoplasia. Angio-MRI is also important to evaluate the tortuosity of the aortic bifurcation and iliac arteries and identify atherosclerosis.

Before the procedure, a Foley catheter is introduced into the bladder and filled with a mixture of 20–30 % iodinated contrast medium and 70 % normal saline solution. This technique is used as a landmark and provides good orientation to the prostate site with a better understanding of the internal iliac artery branches and related structures, avoiding nontarget embolizations. In patients without indwelling catheter due to urinary retention, the Foley

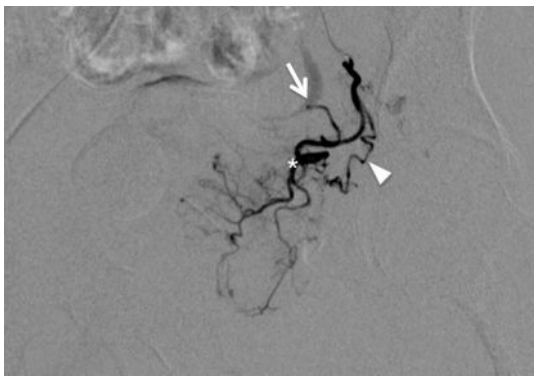

Fig. 1 Digital subtraction angiography showing the microcatheter inserted in the left inferior vesical artery before the origin of bladder (*white arrow*) and rectal (*white arrowhead*) branches. *Asterisk* indicates ideal microcatheter tip position to start embolic agent injection

catheter is removed immediately after PAE. No severe complications have been observed.

Proximal Embolization First

Initial pelvic angiography is performed to evaluate iliac vessels and the prostate arteries. It helps us to better understand the anatomy, identify any atherosclerotic problem, and choose the best technical strategy. Selective digital subtraction arteriogram of the internal iliac artery with a 5F cobra or vertebral diagnostic catheter placed at the common internal iliac trunk is performed to assess the blood supply to the prostate and to perform the internal vesical artery (IVA) catheterization under an ipsilateral 25–55 ° oblique view. For the ipsilateral internal iliac artery approach, the Simmons or the vertebral and cobra catheters with a Waltman loop can be used.

After entering the inferior vesical artery, vasodilator (nitroglycerine or isosorbide mononitrate) is injected through the microcatheter to prevent vasospasm and to increase artery size to facilitate microcatheter navigation and distal positioning. The microcatheter should cross any collateral branch to the bladder, rectum, corpus cavernosum, gonad, or penis and be placed distally into the prostatic artery before its branching to the central gland (urethral group of arteries) and peripheral zone (capsular group of arteries) (Fig. 1). At this point, an additional dose of vasodilator is injected to increase the diameter of the intraprostatic arteries so they can receive more embolic. We have used 5–10 mg of isosorbide mononitrate when the microcatheter is at the IVA and an additional 5–10 mg at the prostatic artery before embolization. Collimation with very slow embolic injection using a 1 mL syringe is highly recommended. A negative road map is useful during embolic injection. We have used 300–500 μm Tris-acryl gelatin microspheres (Merit Medical Inc.). To each 2 mL syringe of microspheres, we add 10 mL of iodinated contrast medium and 10 mL of saline, resulting in a total volume of 22 mL of 50 % contrast and 50 % normal saline solution. We think that a high dilution and very slow injection with 1 mL injection syringe is essential to avoid early proximal occlusion and obtain diffuse gland parenchymal ischemia. We do recommend to embolize slowly and reduce fluoroscopy exposure as much as possible. When reaching near stasis, a manual injection of contrast is performed with a 3 mL syringe before proceeding to the second step to observe any collateral shunts.

Then, Embolize Distal

At this point, the microcatheter should be advanced into the prostatic parenchyma branches for an intraprostatic embolization. Because benign prostatic hyperplasia develops primarily in the periurethral region of the prostate, the urethral group of arteries should be embolized first. The urethral and capsular intraprostatic groups of arteries should be embolized separately. Despite stasis, we have observed that there is potential for prostate enlargement and symptom recurrence after embolization as a result of microvessels that can recanalize the prostate gland. After moving forward into the intraprostatic branches, a very slow manual injection digital subtraction angiography (DSA) may demonstrate some of these microvessels, and more embolic can be delivered. The physician must be caution during injection, because extravasation may occur when the microcatheter is wedged into the gland. At least 30–50 % additional embolic can be delivered into the prostate gland using this technique. After this second and true stasis, the microcatheter should be retracted to the origin of the IVA and a manual contrast injection run performed for final control as well as to search for additional prostatic branches (Fig. 2).

The question may arise: why not embolize distally first and then proximally? The rationale behind the PErFecTED technique is that when the microcatheter is at the origin of the prostatic artery, the embolic injection is under direct flow with homogeneous distribution. We do not start with the microcatheter positioned at the intraprostatic group of arteries because they are very small, irregular, and tortuous, which can make navigation difficult. While positioning the microcatheter into one intraprostatic branch, another may be dissected, spasm, or form a clot from stasis during embolic injection. We have also observed that after distal embolization, the microcatheter moves backward (proximally) into the IVA. In our experience, we believe that the procedure is more likely to be successful if proximal embolization is performed before distal embolization. In

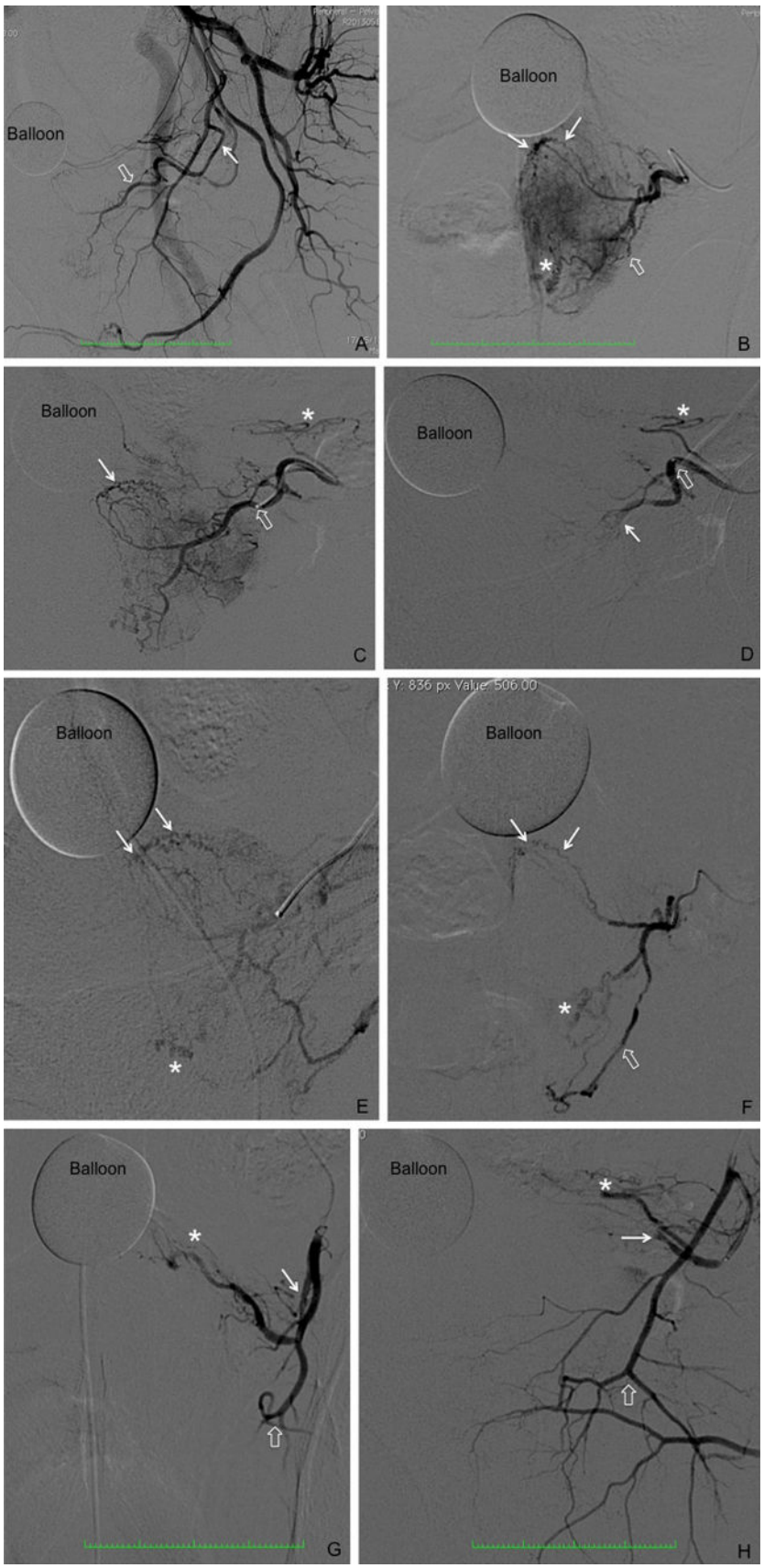

Fig. 2 (**A**) Left internal iliac arteriogram under ipsilateral oblique perspective showing inferior vesical artery (*white arrow*) arising from obturator artery. Note that left prostatic artery and its branches (*open arrow*) are positioned inferior to balloon filled with contrast medium. (**B**) Digital subtraction arteriogram under posterior–anterior perspective showing inferior vesical artery and its intraprostatic branches feeding left portion of median lobe (*white arrows*) and left peripheral zone (*open arrow*). Note central gland is more hypervascular with corkscrew pattern (*asterisk*). (**C**) Ideal microcatheter tip positioning (*open arrow*) distal to some bladder branches (asterisk) for embolic agent injection. Observe corkscrew pattern (*white arrow*) feeding median lobe immediately bellow Foley balloon. (**D**) Arteriogram with near stasis showing bladder branches are still patent (*asterisk*). Note microcatheter tip moved back due to distal resistance during embolic injection. Note occlusion of left prostatic artery (*white arrow*). This is the perfect moment to move microcatheter forward into the gland for additional embolic agent delivery. After advancing microcatheter very distal into prostate parenchyma, many intraprostatic branches are still patent and need to be filled with more embolic agent. Observe median lobe branch (*white arrows*), capsular branch (*open arrow*), and corkscrew pattern in central gland (*asterisk*) under oblique (**E**) and posterior-anterior (**F**) views. Digital subtraction arteriogram after left prostatic artery embolization with total devascularization of left hemiprostate and contrast medium reflux to some bladder branches (*asterisk*) and to obturator artery (*open arrow*) under (**G**) posterior-anterior and (**H**) ipsilateral oblique perspectives. Note occlusion of left inferior vesical artery (*white arrow*)

theory, larger volumes of embolic delivered correspond to greater ischemic areas, coagulative necrosis, change in tissue consistency, prostate shrinkage, urethral relief, and lower urinary tract symptoms improvement. Using the standard technique, infarcts have been seen in two thirds of the prostates, exclusively in the central gland on the embolized side. They were mostly characterized by initial hyperintensity on T1WI and predominant hypointensity on T2WI, and they tended to become smaller and isointense to the remaining central gland over time. Prostate volume reduction has been observed in patients with and without infarcts, but the presence of infarcts is associated with greater volume reduction [4]. Since we added the second step to the PErFecTED technique, we have observed infarcts in all patients. We attribute infarcts to hemorrhagic necrosis, proteinaceous content, and blood breakdown products—especially methemoglobin—and their associated T1-shortening effects. This is supported by histopathological examination of tissue samples from two patients referred to transurethral resection of the prostate after PAE, as previously reported [5], in which periurethral prostatic tissue showed foci of vascular occlusion by the embolic, foreign body chronic inflammatory reactions, as well as large areas of coagulative necrosis.

We have observed significant clinical lower urinary tract symptoms improvement even among the third of patients without prostatic ischemic areas [4]. Our hypothesis is that PAE mimics medications used for benign prostatic hyperplasia, relaxing the smooth muscle (α-blockers) and reducing prostate size (5-alpha-reductase inhibitors). Softer and smoother prostate feeling under digital rectal examination has supported this finding after PAE. To our knowledge, this is the first time this theory has been suggested in the medical literature.

Patients treated with the PErFecTED technique have moderate postembolization syndrome, including dysuria, urethral burning, and pollakiuria. Antibiotics, oral hydration, nonopioid pain relievers, and nonsteroidal anti-inflammatory drugs are recommended. Laxative diet and medication are useful for constipation. As a result of concern over risk of urinary retention, we maintain α-blockers for 1 week after PAE because of their affect on smooth muscle tone. For relevant prostate inflammation and edema after embolization, corticosteroids can be used for symptom improvement.

Another lesson we have learned concerns placement and inflation of the Foley catheter before embolization when using the Foley balloon technique [3]. We observed that patients with very large prostates, especially with prominent medium lobes, who do not have urine in the bladder during Foley introduction have a greater chance of trauma to the median lobe and consequent hematuria. If this happens, the Foley catheter and antibiotics should be maintained for 1 week after PAE under the urologist's supervision. After a standard successful procedure, the Foley catheter should be removed immediately after PAE to observe voiding, and the patient can be discharged home the same day.

Our experience suggests that the PErFecTED technique for PAE leads to greater ischemia and infarction than previously described methods. Although embolizing proximally first is counterintuitive, this technique allows better distribution of embolic material in the intraprostatic arteries and reduces risk of spasm or thrombus. Subsequent distal investigation completes occlusion and stasis of blood flow to the prostatic parenchyma. Long-term follow-up data are needed, but we believe that the PErFecTED technique has the potential to improve the already promising clinical results of PAE for treatment of benign prostatic hyperplasia.

Conflict of interest Francisco C. Carnevale, Airton Mota Moreira, and Alberto A. Antunes declare that they have no conflict of interest.

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