Basiouny et al. Egypt J Radiol Nucl Med (2022) 53:120
https://doi.org/10.1186/s43055-022-00797-x

Egyptian Journal of Radiology and Nuclear Medicine

RESEARCH

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# Anatomical variants in prostatic artery embolization in treatment of benign prostatic hyperplasia

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## Abstract

**Background:** Benign prostatic hyperplasia (BPH) is the most prevalent benign tumor in aged men, and its prevalence is rising with age reaching 8% in the fourth decade of life and up to 90% in the ninth decade. PAE has long been considered as a safe and effective minimally invasive therapy option for individuals with moderate to severe lower urinary tract symptoms caused by prostatic hypertrophy. Because of the varying degrees of atherosclerosis seen in the elderly, PAE is generally a difficult treatment that necessitates a particular amount of knowledge of anatomy and a specific set of abilities. It is critical to emphasize anatomical information about PA that is required for a successful PAE, as well as radiation exposure factors that can be helpful in such a protracted treatment. This thesis provides a pictorial review of PA anatomy and prevalence of related anatomical variants, besides additional anatomical and radiation dosage concerns, and knows the important effect of the anastomosis on non-target embolization as in our study we included large number of cases (83 patients) to cover all types of variations and different types of anastomosis all were covered.

**Results:** A total of 83 patients (166 sides) were analyzed. Double arterial supply on the same side was noted in 1 patient (1.2%). In 3 patients (3.6%), only a unilateral PA was identified. PA origin frequencies were computed. Penile, rectal, vesical anastomoses, and anastomosis with the other side were identified with 7 (8.4%), 3 (3.6%), 2 (2.4%), and 8 (9.6%) of PAs, respectively. Mean skin radiation dose was 479 mGy.

**Conclusions:** When treating BPH with PAE, understanding PA anatomy is critical for achieving the best results. The anatomy of the PA is critical for preventing non-target embolization and is directly related to the correct identification of the anatomical pattern of the prostate arteries, and we should also take into account the presence of contralateral anastomoses; it is possible to achieve both prostate lobes through catheterization of the prostatic artery on only one side.

**Keywords:** Prostate, Embolization, Prostatic artery embolization, Anatomical variations, Prostatic anastomosis

## Background

Benign prostatic hyperplasia (BPH) is the most prevalent benign tumor in aging men, and its prevalence rises with age, reaching 8% in the fourth decade of life and up to 90% in the ninth [1].

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Lower urinary tract symptoms (LUTS) include frequency, nocturia, urgency, hesitancy, reduced and interrupted stream, and inadequate bladder emptying [2]. All of these symptoms have a significant influence on day-to-day living and sleeping habits [3].

Treatment options for BPH-related complaints are influenced by morbidity and quality-of-life issues, as well as the patient's feeling of discomfort. When symptoms begin to compromise with everyday activities, medical treatment should be initiated before any sort of surgical intervention [4].

Because of the considerable morbidity associated with TURP, new minimally invasive procedures have to be developed and advanced. In contrast to surgical procedures that need more thorough anesthetic preparations, percutaneous embolization is the least invasive of all therapeutic options since it does not require surgical incisions and may be performed under local anesthesia [5].

PAE is a minimally invasive, image-guided treatment that has been found to be efficacious in the symptomatic alleviation of LUTS associated with BPH with minimal post-procedural consequences [6].

It has demonstrated promising results in terms of short- and medium-term outcomes, including a decrease in prostate volume and a considerable reduction in clinical symptoms [7].

Because of the different degrees of atherosclerosis that are typical in the elderly, PAE is usually a complex treatment that necessitates a thorough understanding of artery anatomy as well as a set of abilities. It is crucial to highlight critical anatomical facts linked to PA that are necessary for effective PAE, as well as radiation exposure concerns that can be useful in such a relatively lengthy process [8].

When selective prostatic arterial catheterization and embolization are done on at least one pelvic side, PAE is deemed technically effective [9]. The precise identification of the anatomical pattern of the prostate arteries is closely connected to the effectiveness of PAE and the elimination of non-target embolization. We should also examine the existence of contralateral anastomoses, as catheterization of the prostatic artery on only one side allows us to embolize both prostate lobes [10].

### Aim of the work

The aim of the study is to illustrate the pelvic vascular anatomy relevant to PAE, including common variations, and focusing on percentage of anatomical variations of prostatic artery origin at Egyptian patients.

## Methods

*Type of study*: case study.

*Study period*: 2 years

### Study population

#### *Inclusion criteria*

- Patients accepting to participate in the study.
- Male patients 40 years old or more.
- Prostate volume > 50 cc
- Patient with prostatic enlargement with moderate-to-severe LUTS not responding to medications for at least 6 months (International Prostate Symptom Score (IPSS) > 18 and/or quality of life (QOL) > 3) or under acute urinary retention that has been refractory to medical therapy.

#### *Exclusion criteria*

Patients refused to participate in the study, excluding patients with proven malignancy, renal failure, bladder diverticulum, active urinary tract infections, neurogenic bladder, abnormal coagulation profile, or allergies to contrast media it was done.

- Sampling method: convenience sample.
- Sample size*: 83*

### Ethical considerations

Informed consent was obtained from all patients before inclusion in the study.

### Study tools

- Full history taking.
- International Prostate Symptom Score (IPSS) and the quality of life (QoL) related to LUTS (created in 1992 by the American Urological Association).
- PSA level (Free/Total).
- Measuring the prostatic volume and post-voiding residual urine using pelvic ultrasound and trans-rectal ultrasound.
- Tru-cut biopsy from prostate to exclude malignancy, if the PSA level is greater than 4 ng/mL or TRUS findings are suspicious.
- Coagulation profile: platelet count and bleeding profile.
- Urine analysis to exclude UTI.

### Study procedures

#### *Patient preparation*

1. All patients were instructed to fast 6–8 h before the procedure.
2. A full explanation of the detailed procedure was given to the patient and informed consent should be taken.
3. Renal function test including serum creatinine will be revised to each patient, and any patient with serum creatinine > 2.0 mg/dL will be excluded from our study.

### Procedure duration

The procedure takes around 30–60 min.

### Method

- Cases were done over angiography Siemens Monoplane machine (Siemens Inc., Germany); most of the cases were done by the second author, with the rest of the cases being done by the first, third, and fourth authors; the patient rested in supine position wearing the hospital gown; sterilization of the right groin was done; puncture of the right femoral artery using a puncture set was done after local anesthesia, 6F vascular sheath; then, a 5F Cobra head catheter (Boston Scientific, Marlborough, MA, USA) is introduced in right femoral artery to catheterize one of the internal iliac artery and then its anterior division; first, we do diagnostic angiographic using digital subtraction angiography (DSA) by a 5F cobra catheter at left side and then at right side, and the tube has been angled at ipsilateral anterior oblique of 30°–50° with cranio-caudal angulation of 10–15 degrees for better visualization of the prostatic artery origin, and then we selectively catheterize the prostatic artery using a 2.7F Progreat microcatheter (Progreat, Terumo, Tokyo, Japan); then, we inject contrast to do selective prostatic artery angiogram in different views for assessment of its course, related anastomosis and prevention of non-target embolization; if non-target embolization is noted, we used to coil the artery supplying the non-target organ to avoid non-target embolization. In other situations, we advance the microcatheter tip distally to bypass the anastomosis point and also target embolization achieved.
- We used the PErFecTED technique described by Carnevale et al. group in which the microcatheter should be advanced distal to any collateral branch the bladder, corpus cavernosum, rectum, or gonads and placed distally in the prostatic artery before its branching to the central gland and peripheral zone. This technique permits better distribution of the embolic material into the intra-prostatic arteries and helps to reduce the risk of spasm or thrombus formation. Since BPH develops mainly in the periurethral region of the prostate, the urethral group of arteries should be embolized first with ensuing distal embolization to achieve stasis of blood flow and completely occlude prostatic parenchymal blood supply.
- In our study, we do not depend on cone beam CT as a regular method for assessment of prostatic artery origin as it was not available in all cases as some cases done at private center with this modality are not available; it is important to catheterize posterior division of internal iliac and external iliac artery if we cannot visualize prostatic artery, or suspecting additional supply but not routinely done. After that, we start embolization of prostate bed using microspheres (300–500 μm) (Merit Medical Systems Inc., South Jordan, UT, USA) mixed with water-soluble iodinated contrast and saline in the ratio 1:1 till we visualize stasis at the PA, and then femoral sheath is removed and manual compression is applied to the groin for almost 10 min till homeostasis is achieved; usually patient is discharged post-procedural on prophylactic antibiotics, and analgesics for 1 to 2 weeks, and then follow-up clinical improvement after 2 weeks at clinic.

It is important to mention the five known origins for the prostatic artery and the technical details related to each type.

And here is the known five types of prostatic artery and the detailed technical details related to each type:

*Type I pattern* The type I pattern is used to describe a common origin of the SVA and IVA arising from the anterior division of the internal iliac artery. This common trunk has variable length and can be difficult to catheterize because of the double S-shaped curve formed between the SVA and IVA. Shorter trunks and sharper IVA curves are harder to access. Catheterization may be additionally complicated by the close distance to the IIA bifurcation into posterior and anterior divisions. The use of angled-curved microcatheters or a wide C-shaped tip in the microwire can help to catheterize this arterial origin [11].

The type I common trunk is divided into two main arteries, the SVA and IVA, and afterward the IVA continues as the prostatic artery and its branches (anteromedial and posterolateral) [8].

Most of the time, the umbilical artery also originates from the common trunk. In most cases, the IVA also gives branches to the seminal vesicle and, rarely, a rectal branch can be observed in this type of anatomy. As a result, type I anatomy has a risk of non-target embolization involving the urinary bladder, seminal vesicles, and possibly the rectum [11].

*Type II pattern* In type II pattern, the prostatic artery originates from the anterior division of the IIA independent from and inferior to the SVA origin. It is usually a long and tortuous artery, and easier to access than type I. It can also supply branches to the seminal vesical or rectum. In this case, its long trajectory results in lower risk of non-target embolization; however, if reflux of particles occurs, they may reach the IPA or inferior gluteal artery territories, which can lead to gluteal, penile, muscular, and skin injuries [11].

In *type III pattern*, the prostatic artery arises from the upper or middle third of the obturator artery. It is a long artery with tortuous angled origin. It is important to differentiate this artery from the pelvic floor branches, which typically are straight and short branches arising from the lower third of the obturator artery, just proximal to its terminal bifurcation at the obturator foramen. When performing embolization in this type of anatomy, reflux of embolic material can lead to non-target embolization to the obturator artery territory. This may result in bone infarcts, which are usually asymptomatic and can be diagnosed by magnetic resonance imaging [8].

The obturator artery shows high variability in its origin and may arise from the anterior or posterior division of the IIA, from the inferior epigastric artery or from the external iliac artery [11].

*Type IV* prostatic artery arises from the upper or middle third of the IPA and is the most frequent pattern in the literature, yet it was not the most common type at our study [8].

Most of the time, it gives a branch supplying the rectum. This pattern has important technical considerations, with frequent association with rectal branches (43.8%), which in turn can lead to hematochezia and rectal ulcers. Another risk associated with this pattern is reflux of the embolic material to the IPA territory, including the corpus cavernosa and penis [11].

*Type V pattern* Less common origins that cannot be categorized as types I–IV are included in Type V. It can be observed as a native prostatic artery or as a consequence of prostate revascularization due to obstructive atherosclerosis or in patients who underwent a second embolization session [11].

This type includes origins from the posterior division of the IIA, from the accessory internal pudendal artery (aIPA), from the inferior epigastric artery, from the IIA anterior division trifurcation or quadrifurcation, from distal segments of the IPA and the obturator artery, and others [8].

The most frequent and important variation within type V is the origin from the aIPA. The aIPA has usually a parallel and cranial trajectory relative to the IPA. It results in short prostatic branches that can lead to a higher risk of reflux of microparticles. Most of the time, additional protection is needed by occluding the distal aIPA with coils or gelatin sponge to avoid non-target embolization to the pudendal territory. It also has important anastomotic channels with the IPA that should be protected when high flow is also present [11].

**Table 1** Statistical data analysis for different ages enrolled in our study

| | | |
|---|---|---|
| Age (years) | Mean ± SD | 56.69 ± 6.45 |
| | Range | 45–68 |

**Table 2** Percentage of each origin for prostatic artery in our study

| | No | % |
|---|---|---|
| Common origin with superior vesical artery (Type I) | 81 | 49.1 |
| Anterior division IIA (Type II) | 36 | 21.8 |
| Obturator (Type III) | 30 | 18.2 |
| Internal pudendal artery (Type IV) | 15 | 9.1 |
| Other origins (Type V) | 3 | 1.8 |
| Total | 165 | 100.0 |

**Table 3** Percentage of anastomosis between prostatic artery and penile, rectal, vesical, and other side in our study

| | | |
|---|---|---|
| Anastomosis | Negative | 60 (72.3%) |
| | Penile anastomosis | 7 (8.4%) |
| | Vesicle | 2 (2.4%) |
| | Rectal | 3 (3.6%) |
| | Other side | 8 (9.6%) |
| | Rectal and other side | 2 (2.4%) |
| | Rectal + Vesicle + Other side | 1 (1.2%) |

In this table, we can see the percentage of anastomosis noted at the performed cases as following penile, rectal, vesical anastomoses, and anastomosis with the other side were identified with 7 (8.4%), 3 (3.6%), 2 (2.4%), and 8 (9.6%) of PAs, respectively.

Out of these cases, 3 cases with penile anastomosis developed minor penile ulcer (3.6%) and 2 patients with rectal anastomosis developed minimal hematochezia (2.4%) for few days post-procedure and one patient with vesical anastomosis complained of signs of cystitis and self-limited hematuria (1.2%); all these complications were managed by analgesics and antibiotics with no major complications noticed.

**Table 4** Comparison between our study and De Assis et al. [11] and Bilhim et al. (2012) [12] classifications as regard the percentage of origin of prostatic artery

| Origin of prostatic artery | Our study (%) | De Assis et al. [11] (%) | Blhim et al. (2012) (%) |
|---|---|---|---|
| Common origin with superior vesical artery (Type I) | 49.1 | 28.7 | 20.1 |
| Anterior division of ILA (Type II) | 21.8 | 14.7 | 24.8 |
| Obturator artery (Type III) | 18.2 | 18.9 | 12.6 |
| Pudendal artery (Type IV) | 9.1 | 31.1 | 34.1 |
| Other origins (Type V) | 1.8 | 5.6 | 8.4 |

#### Interpretation of results

Technical success with percutaneous embolization is defined as stasis in the prostatic artery with no contrast uptake in control images as demonstrated by intra-operative imaging.

## Results

There were a total of 83 patients (165 sides) studied. In one case, there was double arterial supply on the same side (1.2%). Only a unilateral PA was found in three patients (3.6%). The frequency of PA origins was calculated. Penile, rectal, vesical, and anastomosis with the opposite side were found in 7 (8.4%), 3 (3.6%), 2 (2.4 percent), and 8 (9.6%) of Pas, respectively, and the 2 combined rectal and other side (2.4%) plus 1 patient with combined rectal, vesical, and other side (1.2%). Mean skin radiation dose was 479 mGy (Tables 1 and 2).

In 35 cases, bilaterally symmetrical PA sources were discovered (42.2%). Out of the 35 individuals with symmetrical origins, 23 (65.7%) came with common origin with SVA, 1 (2.9%) from IPA, 5 (14.3%) from OA, and 5 (14.3%) straight from the anterior division (Tables 3 and 4).

All these complications were self-limited and implicated the important role of prostatic anastomosis knowledge to avoid complications and it is highly important to avoid non-target embolization and patients should be informed about it.

In our study, we encountered all types of anatomical variations, and here is a demonstration of some of cases, a patient with bilateral double prostatic artery demonstrated as both type I (common origin with superior vesical artery) and type II (separate origin to superior vesical artery) (Figs. 1 and 2).

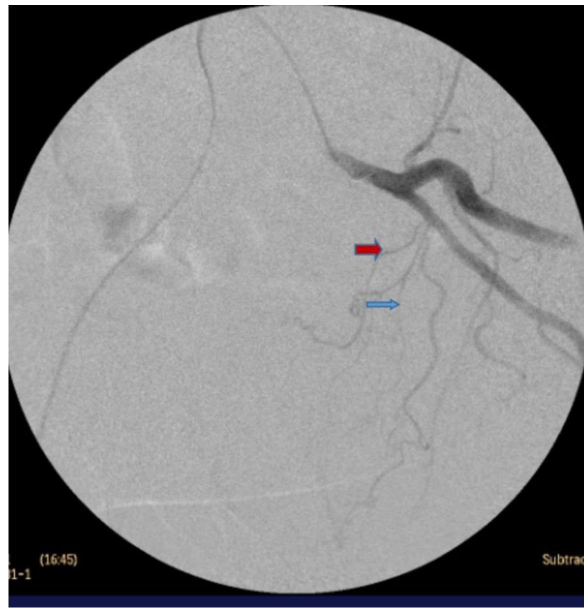

**Fig. 1** Angiography image, showing double prostatic arteries for left side, common origin with superior vesical artery (blue arrow) and separate origin of superior vesical artery (red arrow)

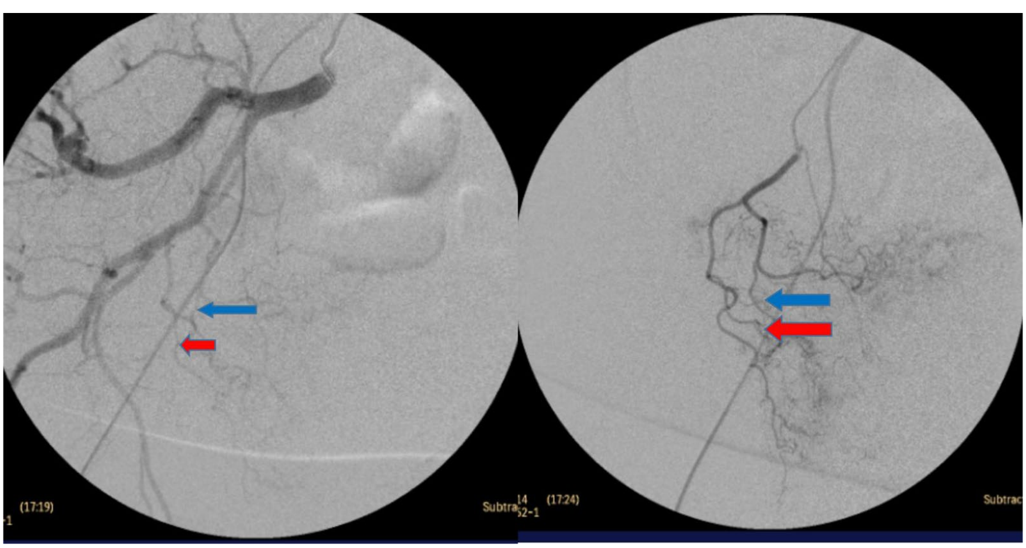

**Fig. 2** Angiography images, showing double prostatic arteries for right side, common origin with superior vesical artery (blue arrow) and separate origin of superior vesical artery (red arrow)

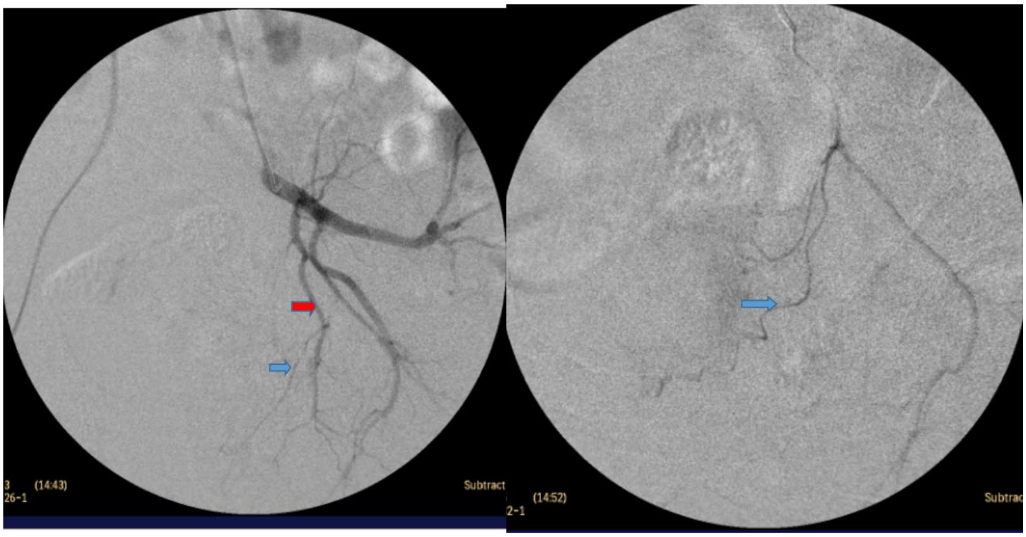

**Fig. 3** Angiography images showing the prostatic artery (blue arrow) arising from the left obturator artery (red arrow)

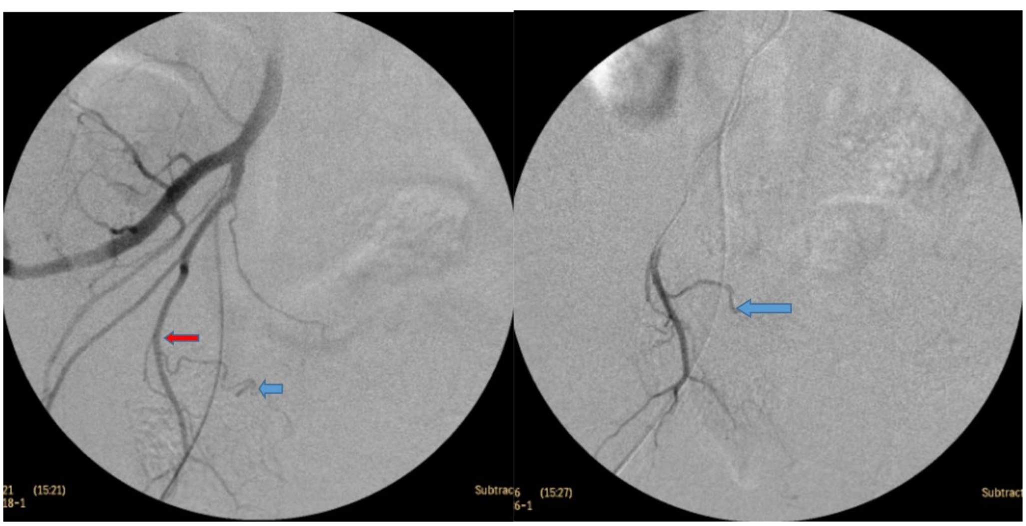

**Fig. 4** Angiography images showing the prostatic artery (blue arrow) arising from the right obturator artery (red arrow)

Another patient with prostatic artery arising from obturator artery from the anterior division of ILA at both sides (type III) (Figs. 3 and 4).

In addition to another patient with prostatic artery origin being a common origin with superior vesical artery from each side (type I) (Figs. 5 and 6), here we can see ultrasound images for prostate volume which nearly estimated 117 g preoperative (Fig. 7).

Moreover, a patient is presented with prostatic artery origin (type V) at both sides, right side showing prostatic artery arising from the obturator artery arising from the posterior trunk of the internal iliac artery (Fig. 8) and left side arising from the obturator artery which arises from external iliac artery (Fig. 9).

Another case was presented with right-side prostatic artery arising from the obturator artery of the anterior

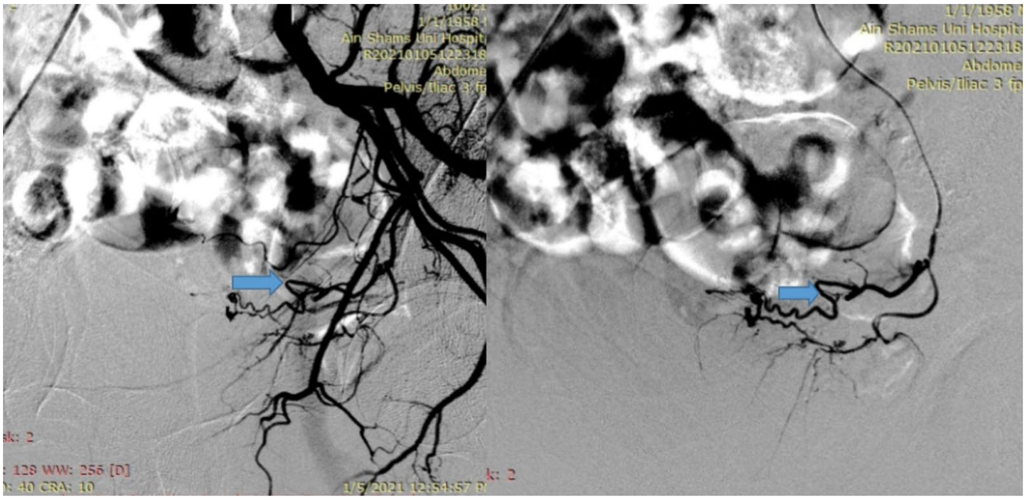

**Fig. 5** Angiography images showing the origin of left prostatic artery (blue arrow) as a common origin with superior vesical artery

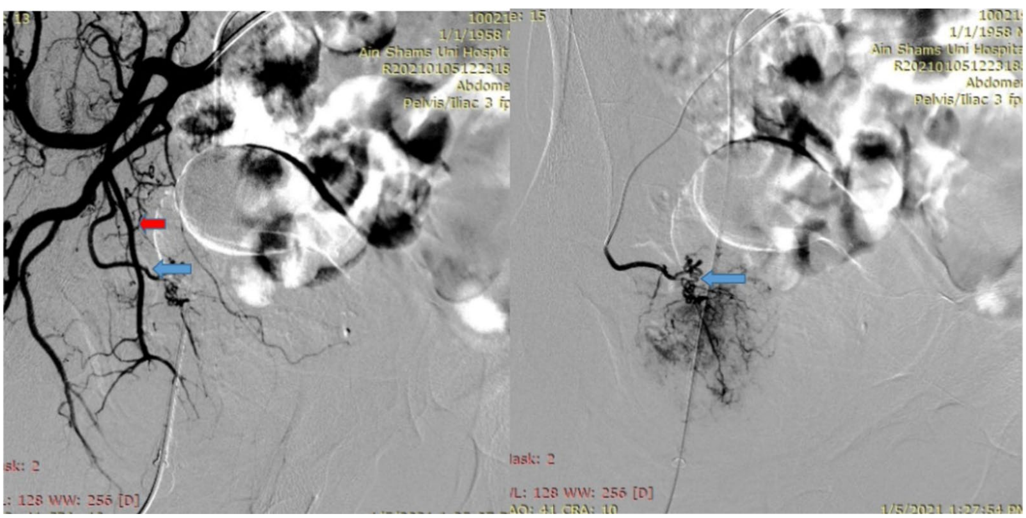

**Fig. 6** Angiography images showing the origin of right prostatic artery (blue arrow) as a common origin with superior vesical artery (red arrow)

division of IIA (type III) (Fig. 10) and left side prostatic artery arising as common trunk with superior vesical artery (type I) (Fig. 11); in this case, we can see images showing that we used coils to occlude the left superior vesical artery supplying the urinary bladder to avoid non-target embolization of the urinary bladder and safely embolize the prostate (Fig. 12). And also anastomosis between both pelvic right and left sides was demonstrated in this case (Fig. 13).

And here is a last case of a patient with right-side prostatic artery arising below superior vesical artery (type II) (Fig. 14) and left side prostatic artery arising from pudendal artery (type IV) (Fig. 15).

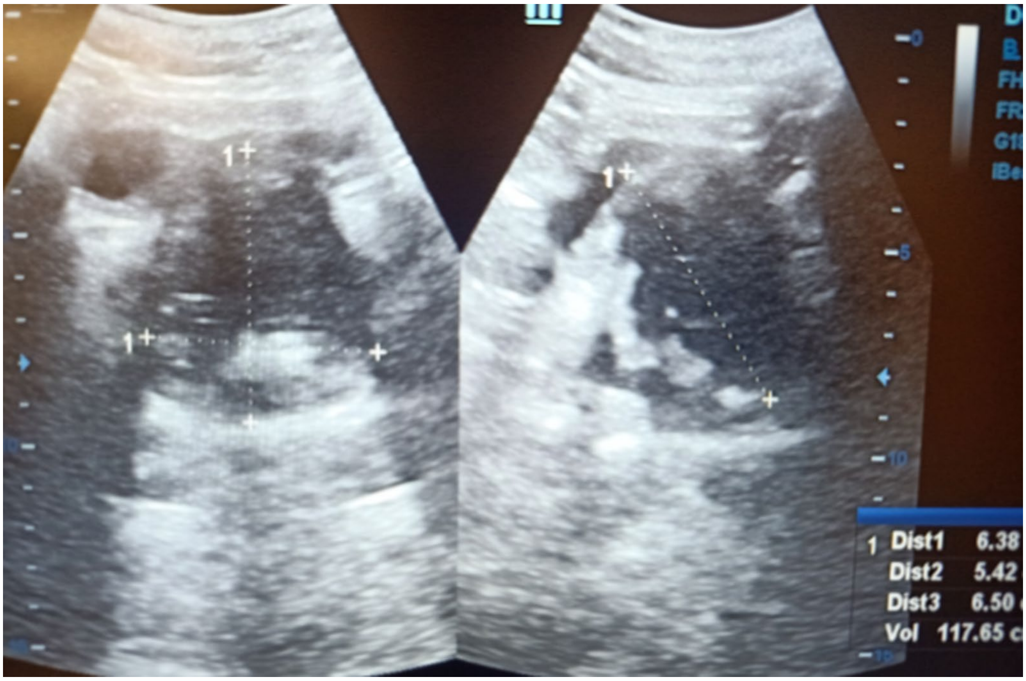


**Fig. 7** Ultrasound image for prostate volume pre-embolization showing, prostate of estimated volume = 117 g

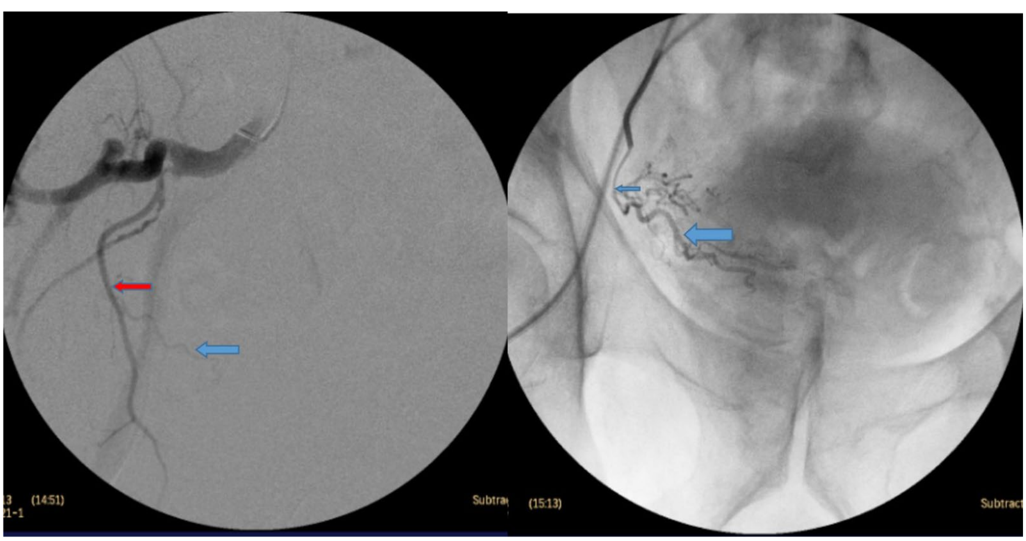

**Fig. 8** Angiography images showing the origin of right prostatic artery (blue arrow) from obturator artery (red arrow), from posterior trunk of IIA

## Discussion

For several decades, interventional radiologists have used prostatic artery embolization to treat bleeding from various prostatic sources [13]. Initially, prostatic artery embolization was reported for the treatment of benign prostatic hyperplasia complicated by hematuria not responding to medications in 2000 [12]. In 2008, prostatic artery embolization was done as an effective

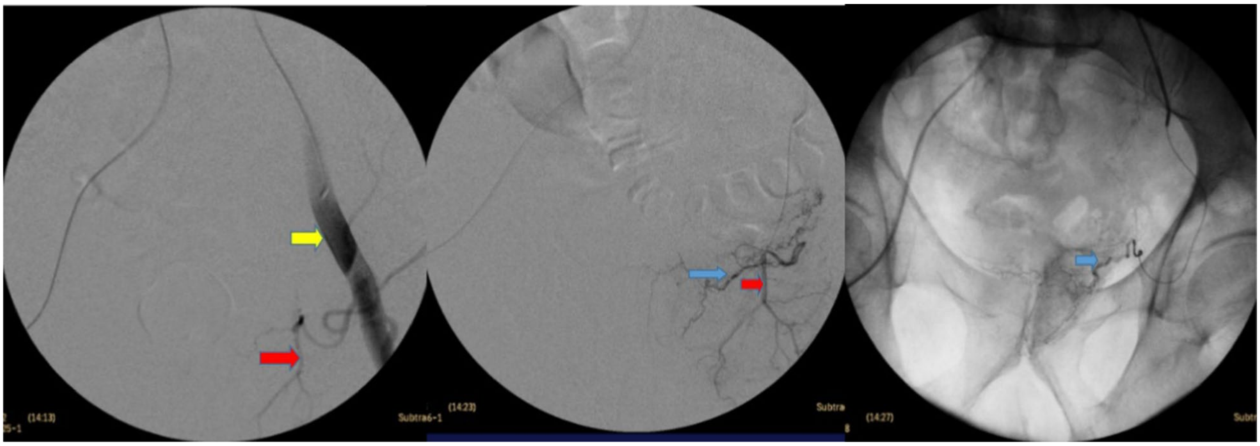

**Fig. 9** Angiography images showing the origin of left prostatic artery (blue arrow) from obturator artery (red arrow), from EIA (yellow arrow)

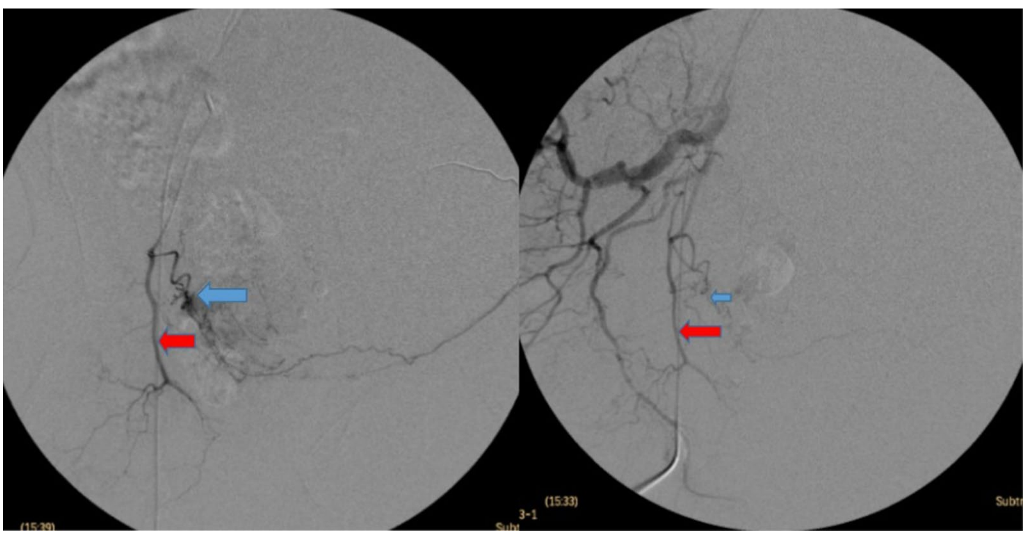

**Fig. 10** Angiography images showing the origin of right prostatic artery (blue arrow) from obturator artery (red arrow), from anterior trunk of IIA

minimally invasive procedure to address lower urinary tract problems caused by benign prostatic hyperplasia.

The Society of Interventional Radiology (SIR) issued a first statement on prostatic artery embolization for benign prostatic hyperplasia (BPH) in 2014, stating that PAE is a safe and effective technique for BPH and urging more clinical research [14].

This research focuses on the anatomy of the PA and its variations in great details [8]. Almost half of the patients had a symmetrical origin of PA; this knowledge should be used to avoid using PD, radiation, and contrast when looking for the contralateral PA. If the origin is not immediately apparent on DSA, one should begin by looking at SVA, which accounts for around half of all PA origins. According to the PiscoGroup, IPA is the most prevalent source of PA (35%), followed by SVA (20%) [12]. Carnevale group indicated 31.1 and 28.7% IPA and SVA origins, respectively, while SVA was

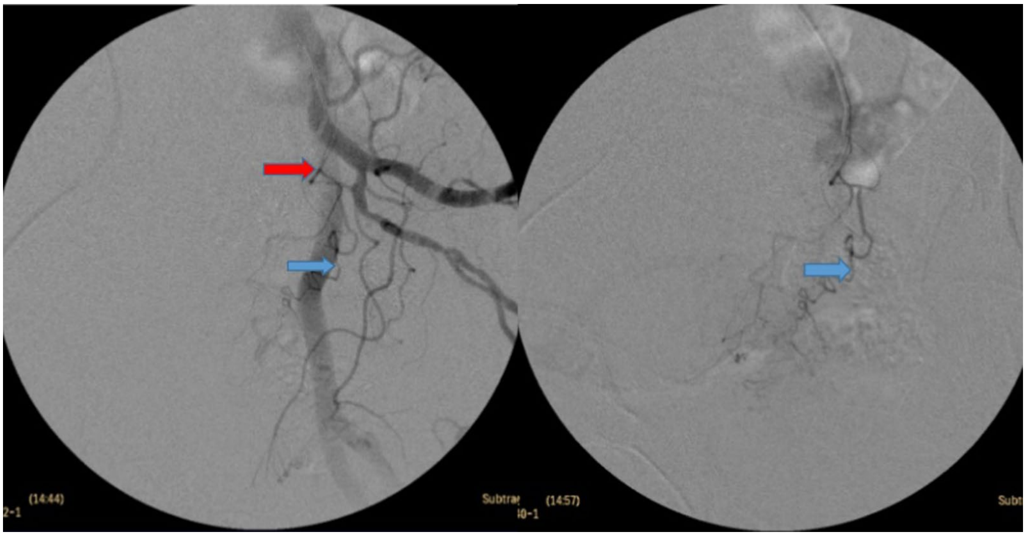


**Fig. 11** Angiography images showing the origin of left prostatic artery (blue arrow) with common origin with superior vesical artery (type I) origin

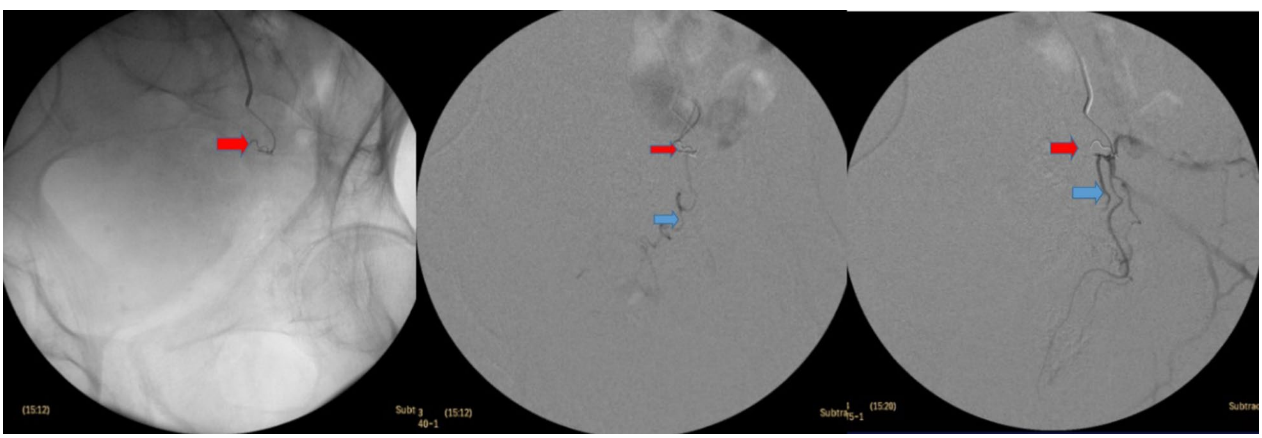

**Fig. 12** Angiography images showing coil (red arrow) occluding superior vesical artery origin to avoid non-target embolization to the urinary bladder, and prostatic artery marked by blue arrow

followed by IPA on [15]. This is consistent with reports from German and American groups indicating that SVA origin is the most prevalent, with 35 and 27.5%, respectively [11]. In our series, the most prevalent origin was SVA, followed by direct origin below SVA (type II), with 49.1 and 22.1%, correspondingly [16, 17].

Anastomoses interconnecting both hemi-prostates were observed in 13.2% of the patients in our series. The anastomosis might be extensive enough allowing for total prostatic embolization through unilateral technique. Extensive anastomosis is documented to occur in 3% of cases in the literature [18]. This is especially important when the prostate supply is only recognized on one side. The PErFecTED approach proposed by the Carnevale group may be the best way to identify the real amount of anastomosis [10].

Protective coils/Gelfoam are hugely important instruments in some situations, allowing safe embolization of the target arteries. Although coils are the most typically utilized material, Gelfoam has also been discussed in the

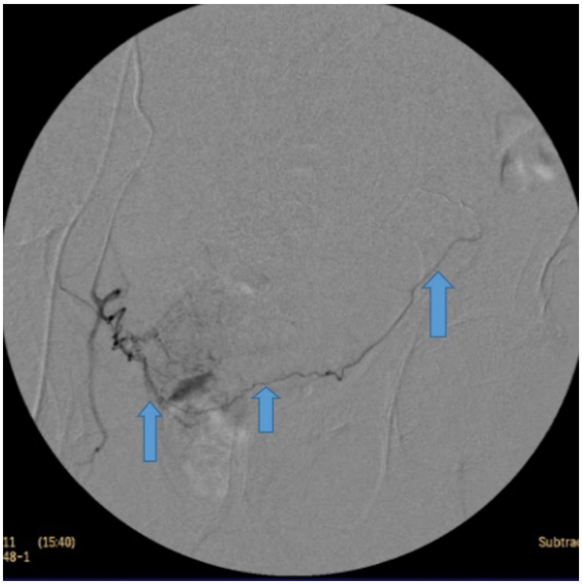

**Fig. 13** Angiography image showing right-side anastomosis with the other pelvic side (blue arrows)

literature [19]; in our study, we utilized coils to preserve the urinary bladder, rectum, and other pelvic organs, avoiding non-target embolization.

The radiation exposure was measured in all cases; the mean radiation dose was 479 Gy $cm^2$ per procedure (range, 124–1460 Gy $cm^2$) compared to 450.7 Gy $cm^2$ (range 248.3–791.73 Gy $cm^2$) per procedure according to Andrade et al. [20] and 241.5 Gy $cm^2$ per procedure according to Pisco et al. [3]; in some cases, we have low radiation dose which might be attributed to the lack of usage of cone beam CT [21]; in our study, CBCT accounted for up to 23% of the total radiation exposure and raised the CM use of the procedure and should be considered very carefully according to Burckenmeyer et al. (2021) [22], and in other cases we have higher radiation dose than encountered at the mentioned studies mainly as some patients have atherosclerotic arteries and difficult prostatic artery origin (type V) as in some cases we have prostatic artery origin from external iliac artery which make its identification require multiple imaging series and the usage of different machines makes the radiation dose higher in those cases.

### The limitations of our study

There is no intraoperative CBCT control group in our study.

## Conclusions

Prostatic artery embolization (PAE) is a minimally invasive, image-guided therapy for symptomatic relief in patients with prostate enlargement/benign prostatic hyperplasia associated with benign prostatic hyperplasia with minimal post-procedural complications.

A thorough understanding of PA anatomy is required for treating BPH with PAE in order to improve technical success, decrease problems related to non-target embolization, shorten the procedure, and limit radiation exposure. There are insufficient data to support the regular use of preoperative CTA and intraoperative CBCT to improve safety or effectiveness. In this regard, randomized controlled trials are necessary.

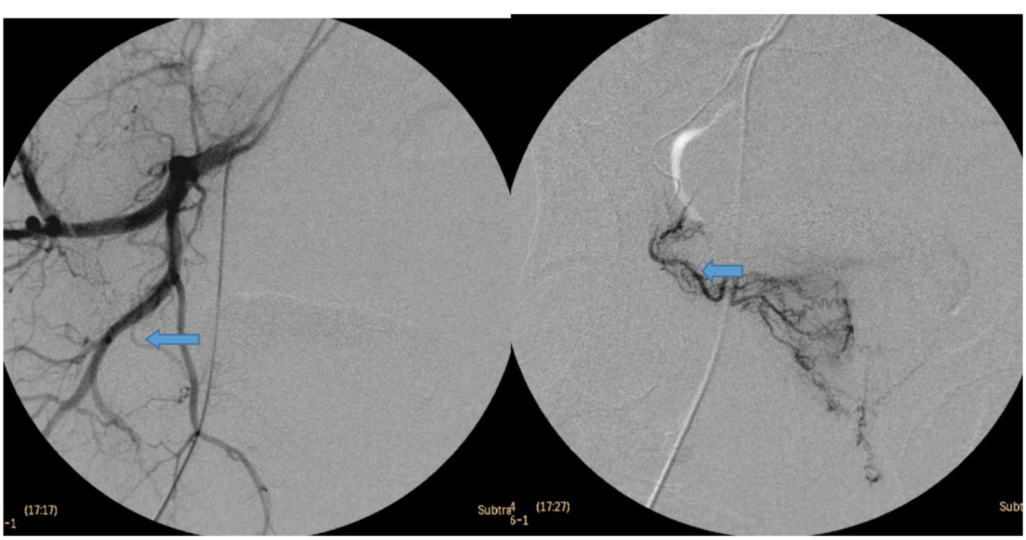

**Fig. 14** Angiography images showing the origin of right prostatic artery (blue arrow) below superior vesical artery


**Fig. 15** Angiography images showing the origin of left prostatic artery (blue arrow) arising from pudendal artery (red arrow)

In our study, we found that the most common origin was type I prostatic artery with nearly half of the prostatic artery origin from this type, although in the literature the most common origin was type IV.

**Acknowledgements**
Not applicable.

**Author contributions**
AA, the corresponding author, contributed by doing ultrasound examinations and providing the preoperative laboratory tests for all the patients and assessing the anatomical variations of the prostatic artery origin for all the patients enrolled in the study and in the interpretation of the results and helped in editing the manuscript and reference collection. AA, the co-author, helped in assessing the different types of anatomical variations of each patient and helped in performing the embolization and interpretation of the data. AH, the co-author, helped in the embolization technique and dealing with the collected data and approving the final submitted version of the paper. SA, the co-author of this paper, have read and approved the final version submitted.

**Funding**
The author declare that there is no funding.

**Availability of data and materials**
All data are available on a software system owned by each of the authors, and the corresponding author has the authority to respond if there is any query.

## Declarations

**Ethics approval and consent to participate**
The protocol was checked and approved by local ethics committee of the Radiology Department, Ain Shams University. The reference number was not applicable.
All patients had been given written consents to participate in this work.

**Consent for publication**
All patients had given their written consents for publication of this work.

**Competing interests**
The authors declare that they have no competing interests.

Received: 2 April 2022 Accepted: 13 May 2022
Published online: 20 May 2022

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