Anatomical variation of the prostatic artery and the impact of its embolization on IPSS in benign prostatic hyperplasia

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SUMMARY

The prostate gland is known for its potential implications, particularly prostate cancer and benign prostatic hyperplasia. It is supplied by the prostatic artery, which shows considerable anatomical variation, directly implicating prostatic artery embolization, an emerging minimally invasive therapy for benign prostatic hyperplasia. Identifying prostatic artery origin variation is essential in order to optimize embolization and improve clinical outcomes. The objective was to investigate the anatomical variation of the prostatic artery using cadaveric dissection and angiographic evaluation, and to assess the impact of this variation on clinical outcomes following prostatic artery embolization. A bilateral cadaveric dissection was conducted on five male pelvis specimens to identify prostatic artery origin. The radiological arm included 54 symptomatic benign prostatic hyperplasia patients undergoing prostatic artery embolization, with prostatic artery origin variation and symmetry documented. IPSS recorded pre-procedure and at 3 and 6 months post-embolization, and statistical analysis was performed.

Cadaveric analysis showed that the prostatic artery most commonly originated from vesical arteries (60%), followed by the obturator (20%) and internal pudendal arteries (20%). Radiologically, vesical origin was also the most frequent (41.7%), followed by obturator (23.1%), internal pudendal (21.3%), and internal iliac artery (13.9%). Symmetrical prostatic artery origin was observed in 83.3% of patients. Prostatic artery embolization produced a significant reduction in mean IPSS, from 24.53 pre-procedure to 16.31 and 11.56 after 3 and 6 months respectively ($p<0.001$). Neither patient age nor prostatic artery origin impacted clinical improvement. The prostatic artery shows marked anatomical variability, with vesical arteries representing the most frequent origin. Prostatic artery embolization is an effective treatment for benign prostatic hyperplasia, producing significant improvement regardless of prostatic artery origin or patient age.

Key words: Prostatic artery – Cadaver – Benign prostatic hyperplasia – Embolization

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INTRODUCTION

The human prostate is a pyramidal gland located below the bladder, comprising distinct anatomical, histological, and pathological regions. Historically, Lowsley (1912) led the initial anatomical division of the prostate gland into five lobes: the middle (median), anterior, posterior and two lateral lobes, with the lateral lobes containing most glandular tissue. Histologically, the gland consists of compound tubuloalveolar glands embedded in a dense fibromuscular stroma, with a two-layered epithelium and occasional corpora amylacea within the lumina (De Marzo et al., 2007). Historically, the posterior lobe was considered the primary site of prostate cancer and the median lobe of benign prostatic hyperplasia. However, the widely accepted zonal classification by McNeal (1988) describes peripheral, central, and transitional zones. The peripheral zone contains about 70% of glandular tissue, and is the most frequent site of cancer; the transitional zone surrounds the urethra and enlarges in older men with BPH; and the central zone, surrounding the ejaculatory ducts, is rarely affected primarily, but may be secondarily involved in malignancy (Ittmann, 2018).

The pelvic region is primarily supplied by the internal iliac artery, which exhibits considerable variability in its branching pattern, with recognized differences related to sex. Awareness of these anatomical variations is of particular importance in pelvic and urological surgeries. Early attempts to classify the branching pattern of the internal iliac artery relied on a simplified division into anterior and posterior trunks from which the smaller branches arise (Carter, 1867; Sharpey et al., 1867; Wilson, 1868). A more detailed and widely adopted classification was later proposed by Adachi (1928), who described five types based on the origin of the gluteal and internal pudendal arteries, whether arising independently or from common trunks. This classification did not consider variations in the origin of the obturator artery previously described by Lipshutz (1918), and was subsequently refined by Ashley and Anson (1941), who incorporated the umbilical artery into the classification scheme. According to Yamaki et al. (1998), the most frequent branching pattern (60–80%) consists of the internal iliac artery branching into the superior gluteal artery, and a common trunk giving rise to both the inferior gluteal and internal pudendal arteries. Less commonly, a common trunk for the superior and inferior gluteal arteries or for the superior gluteal and internal pudendal arteries may be observed, while in some cases all three arteries originate independently.

Lipshutz (1918) reported that the prostatic artery most frequently originated from the anterior division of the internal iliac artery (30%), followed by the obturator artery (15%), the middle rectal artery (10%), the ischiopudendal trunk (10%), and the inferior gluteal artery (5%). In a later anatomical study, Clegg (1955) examined the origin of the prostatovesical artery, and found that 52.9% arose from the common trunk of the inferior gluteal and internal pudendal arteries, 11.8% originated from the umbilical artery or its origin, 11.8% from a common trunk with the vesicodeferential artery, 5.9% from the internal pudendal artery, and 5.9% from the obturator artery. Roberts and Krishinger (1967) similarly reported the ischiopudendal trunk as the most frequent site of origin (37.7%), followed by the obturator artery (23.3%), superior vesical artery (13.3%), inferior vesical artery (13.3%), internal pudendal artery (10%), and, less commonly, the dorsal artery of the penis (3.3%).

The prostatic vascular system is a crucial factor in the growth and function of the prostate; affection of the blood flow to the prostate gland may be involved in the BPH development and control (Carnevale et al., 2013). The prostate receives its arterial blood supply from prostatic branches of variable anatomical origins. According to Teichgraber et al. (2018), superior and inferior vesical arteries typically arise from the internal iliac artery. The inferior vesical artery runs caudally to reach the base of the bladder, supplying the seminal vesicles and the prostate as well. In some cases, the inferior vesical artery shares a common trunk with either superior vesical artery or middle rectal artery, from which the prostatic artery (PA) may arise. The superior vesical artery supplying the superior surface of the bladder may also contribute to prostatic supply. Additionally, prostatic branches may arise from the common

gluteal–pudendal trunk or directly from the internal pudendal artery (Bilhim et al., 2011).

Moya et al. (2017) reported six possible origins for the PA: internal pudendal artery (29.3%), gluteal-pudendal trunk (27.5%), inferior vesical artery (20.7%), middle rectal artery (15.5%), obturator artery (5.2%), and other less common sources. On the other hand, angiographic classification simplifies the PA origin into four main types: a common vesical trunk dividing into superior and inferior vesical arteries; inferior vesical artery arising separately from the internal iliac artery; obturator artery; and internal pudendal artery. Less common origins include the accessory pudendal artery, anterior division trifurcation of the internal iliac artery, posterior division of the internal iliac artery, and inferior epigastric artery (De Assis et al., 2015).

A number of studies reported that the prostate may, in some cases, receive dual arterial supply, with a cranial anterolateral pedicle mainly supplying the transition zone and a caudal posterolateral pedicle supplying the apex and peripheral zone. The anterolateral pedicle often supplies the central gland and BPH nodules, typically arising from the vesical arteries and commonly targeted in embolization procedures. The posterolateral pedicle supplies the peripheral and caudal prostate and may communicate with rectal branches. Anastomoses with surrounding arteries are common and should be considered during embolization (Bilhim et al., 2012; De Assis et al., 2015; Wang et al., 2017).

Prostate tissue remodelling and degeneration are part of the normal aging process, leading to alterations in smooth muscle function, prostate size, enlargement, and fibrosis, which ultimately disturb prostatic function (Liu et al., 2019). BPH is one of the commonest diseases affecting men after the age of forty, with the risk of onset and progression increasing with advancing age. Genetics, diet, and lifestyle also influence the prevalence of the disease (Lim, 2017).

Benign prostate syndrome (BPS) refers to lower urinary tract symptoms and bladder outlet obstruction secondary to BPH (Liu et al., 2019). BPH is regarded as a nodular disease, typically affecting the transition zone rather than the whole prostate. Bladder outlet obstruction does not correlate solely with prostate size but is largely influenced by the location of the adenoma, particularly if situated near the bladder neck or urethra (Nickel et al., 2016). Thus, prostate size and symptom severity are not necessarily correlated. Even small prostates may cause significant symptoms if the adenoma is strategically positioned. Symptoms of BPS typically include delayed initiation of micturition, prolonged voiding time, weak urinary stream, a sensation of incomplete bladder emptying, increased nocturia, frequency, urgency, and dysuria — all of which significantly impact the quality of life in older men (Carnevale et al., 2013).

Treatment decisions for BPS are primarily guided by the impact of symptoms on patients' quality of life. First-line management typically involves pharmacological therapy. Drug therapies for BPH can improve urine flow, but they do not reduce the size of the prostate and can contribute to sexual dysfunction or hypotension as side effects (Bilhim et al., 2012). If medical management fails, surgical intervention may be required. Transurethral resection of the prostate has been for decades the gold-standard surgical treatment for symptomatic BPH, although it carries a morbidity rate of up to 20% (Capdevila et al., 2021).

Prostatic artery embolization has emerged since 2000 as a minimally invasive alternative technique for symptomatic patients, offering comparable clinical outcomes with faster recovery and fewer complications (De Assis et al., 2015). Advantages of PAE include avoiding hospitalization, general anesthesia, and surgery, and reducing the risk of sexual side-effects such as retrograde ejaculation or erectile dysfunction (Franco et al., 2023). PA embolization involves selective embolization of intraprostatic vessels and precapillary arterioles, resulting in irreversible ischemia and an inflammatory response that leads to complete tissue anoxia. Subsequent gland shrinkage occurs following edema resorption and scar formation. Accurate identification of PA vasculature and its origins during embolization is essential to avoid nontarget embolization and to recognize small anastomoses between intraprostatic branches or adjacent arteries (Zhang et al., 2015; Teichgra-

ber et al., 2018). Misinterpretation of the vascular anatomy of the PA and its variations could result in nontarget embolization of periprostatic organs and other structures such as the bladder, rectum, and penis (Pilan et al., 2022).

The International Prostate Symptom Score (IPSS) is a validated and widely used tool for assessing lower urinary tract symptoms related to benign prostatic hyperplasia (BPH). The questionnaire comprises seven questions, each scored from 0 to 5 according to symptom severity. These items assess key urinary symptoms including incomplete emptying, frequency, intermittency, urgency, weak stream, straining, and nocturia, the maximum total score is 35 (Barry et al., 2017). It is designed to assess the severity of symptoms, identify patients who may benefit from intervention, and monitor response to treatment over time. With scores interpreted as follows: 0–7 indicating mild symptoms, 8–19 moderate symptoms, and ≥20 severe symptoms (Naidu et al., 2021). This simple tool remains a core component of both clinical assessment and research in BPH (Zhu et al., 2024).

The aim of the work was to study the anatomical variations of the prostatic artery (PA) using both cadaveric dissection and angiography, and to evaluate the impact of these variations, as well as embolization outcomes on IPSS, through the angiography.

MATERIALS AND METHODS

Cadaveric study

This cadaveric study was conducted in accordance with applicable ethical standards and institutional regulations. Cadaveric specimens were obtained through recognized body donation programs. Specimens were prepared and preserved in 10% formalin solution according to institutional protocols, ensuring proper fixation, ethical compliance, and suitability for anatomical study.

The study was conducted in accordance with the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of October 6 University (protocol code O6U-ERC-0055).

The authors sincerely thank those who donated their bodies to science so that anatomical research and teaching could be performed. Results from such research can potentially increase scientific knowledge and can improve patient care. Therefore, these donors and their families deserve our highest respect.

Fig. 1.- Cadaveric dissection of a right pelvic side showing the PA originating from the vesical artery. 1: Internal iliac artery; 2: Anterior division; 3: Superior vesical artery; 4: Obturator artery; 5: Inferior vesical artery; 6: Prostatic artery; 7: anastomotic branch; 8: Middle rectal artery; 9: Internal pudendal artery; 10: Posterior division; 11: Iliolumbar artery; 12: Lateral sacral artery; 13: Gluteal branches. EIA: External iliac artery; UB: Urinary bladder; SP: Symphysis pubis; P: Prostate.

The cadaveric study was performed bilaterally on five adult male pelvis specimens. Dissection started with the identification, delineation, and separation of both common iliac arteries and their bifurcation into the external and internal iliac arteries. All branches of the internal iliac artery were carefully dissected, with particular attention paid to the origin and course of the PA.

Radiological study (Patients)

The radiological study included 54 patients clinically diagnosed with BPH, aged over 50 years, with an IPSS greater than 19. All patients provided written informed consent to participate in the study. Exclusion criteria included suspicion of prostate cancer, active urinary tract infection, abnormal coagulation profile, or known allergy to contrast media. These criteria were previously applied by Basiouny et al. (2022).

Prostatic artery embolization procedure

Prostatic artery embolization was performed according to standard techniques under intravenous sedation, targeting the PA. All procedures were performed by the second author using a Siemens Monoplane angiography machine (Siemens Inc., Germany). Right femoral artery puncture was performed under local anesthesia, and a catheter was advanced through the femoral artery to the internal iliac artery and its anterior division, using digital subtraction angiography (DSA). Selective catheterization of the PA was performed using a microcatheter. Selective PA angiography was done to assess the arterial course, related anastomoses, and to avoid non-target embolization. Embolic material was introduced into the PA in order to achieve stasis of blood flow and complete occlusion of the prostatic parenchymal supply (Basiouny et al., 2022; Bilhim, 2023). Technical success is identified as successful embolization of all angiographically and/or cone-beam-computed-tomography visible arterial supply to the prostate and stasis in the PA with no contrast uptake in images taken in intraoperative imaging.

It is worth noting that the radiological classification of the PA, as described by Carnevale et al. (2017), shows a slight variation from the traditional anatomical descriptions. Radiologists, for instance, often refer to a common vesical trunk as type I, whereas anatomists usually differentiate between the superior and inferior vesical arteries as separate branches. According to the radiological classification, the PA can arise from the vesical artery (type I), directly from the internal iliac artery (type II), the obturator artery (type III), the internal pudendal artery (type IV), or from less common origins (type V). In this study, we use the term vesical origin more broadly, to refer to any origin involving vesical arteries, allowing for a practical alignment between both anatomical and radiological viewpoints.

Outcome measures

Changes in IPSS were recorded before the procedure, at 3 months and 6 months postoperatively.

Statistical analysis

SPSS version 22.0 software was used for data analysis. Continuous data were presented as mean ± standard deviation, and categorical data were presented as percentages. The t-test was used for pairwise comparisons of continuous variables between groups, and analysis of variance (ANOVA) was applied for comparisons among multiple groups. A p-value < 0.05 was considered statistically significant, and < 0.001 was considered highly significant.

RESULTS

Cadaveric results

In all cadaveric pelvic sides (No = 10), the internal iliac artery exhibited anterior and posterior divisions, but with variable branching patterns. The PA, being the specifically examined vessel, was identified as a direct branch from the vesical artery in six pelvic sides as it passed to supply the urinary bladder (Fig. 1). In two specimens, the PA originated from the obturator artery, and in another two, it originated from the internal pudendal artery. No cases demonstrated a direct origin from the internal iliac artery or other branches. There was no difference in PA origin between both sides in any of the examined specimens (Table 1).

Table 1. Distribution of PA origins observed in cadaveric specimens

PA origin	Number of specimens	Percentage
Vesical artery	6	60%
Obturator artery	2	20%
Internal pudendal artery	2	20%

Radiological results

Anatomical variations of the origin of PA were observed during angiography of all the cases treated with PA embolization included in the current study.

The PA originated from the vesical artery in 45 sides (18 bilateral, 4 from the right side, and 5 from the left). It arose from the obturator artery in 25 sides (11 bilateral, one from the right side only, and two from the left). The PA was found to originate from the internal pudendal artery in 23 sides (bilaterally in 10 cases, from the right in 2, and from the left in 1 case). It originated from the internal iliac artery in 15 sides (bilaterally in 6 cases, from the right in 2, and from the left in 1). Out of the 54 cases, 45 (83.3%) demonstrated symmetrical PA origin on both sides, while 9 cases showed an asymmetrical origin (Table 2 and Fig. 2).

All patients were followed for IPSS measurement before procedure, and at 3 and 6 months after the procedure. A progressive improvement in IPSS was observed at both time points. The mean pre-procedure IPSS score of 24.53 dropped to 16.31 after 3 months and to 11.56 after 6 months. This improvement was statistically analyzed and showed highly significant differences between the three measurements (Tables 3-4 and Fig. 3).

The impact of the origin of PA (after excluding patients with asymmetrical origin) as well as patient age, on the IPSS was also tested and no statistically significant differences were detected (Tables 5-6).

It is to be noted that all specimens included in the study contributed to the statistical analysis. However, only representative images from cadaveric dissections and radiological studies were selected to illustrate key anatomical findings. Images of lower quality or preservation status were excluded from publication to maintain clarity and scientific rigor.

DISCUSSION

In the present study, the main origin of the PA was found to be from the vesical arteries. There is an obvious variation in the description of the vesical artery origin. The classical anatomical classification points to distinct origins of both superior vesical artery and inferior vesical artery, both originating from the anterior division of the internal iliac artery. The superior vesical represents the post foetal fate of the umbilical artery, with its terminal part obliterated forming the medial umbilical ligament. While the inferior vesical artery —also referred to as the vaginal artery in females— descends caudally to supply the pelvic genital organs. However, different studies have shown variable origins of the vesical arteries including a common trunk, multiple superior vesical arteries or a shared origin of inferior vesical artery with other pelvic branches such as middle rectal or obturator arteries (Bilhim et al., 2011; Mamatha et al., 2015; De Treigny et al., 2017). That is why we adopted the term “vesical origin” in the present work, to bypass the origin dilemma.

Table 2. Distribution of PA origins observed in patients

Origin	Symmetrical origin	Right side	Left side	Total	Percentage
Vesical	18 cases (36 sides)	4 sides	5 sides	45 sides	41.7 %
Obturator	11 cases (22 sides)	1 side	2 sides	25 sides	23.1%
Internal pudendal	10 cases (20 sides)	2 sides	1 sides	23 sides	21.3%
Internal iliac	6 cases (12 sides)	2 sides	1 sides	15 sides	13.9%
Total	45 cases (90 sides)	9 cases (18 sides)		54 cases (108 sides)	100%

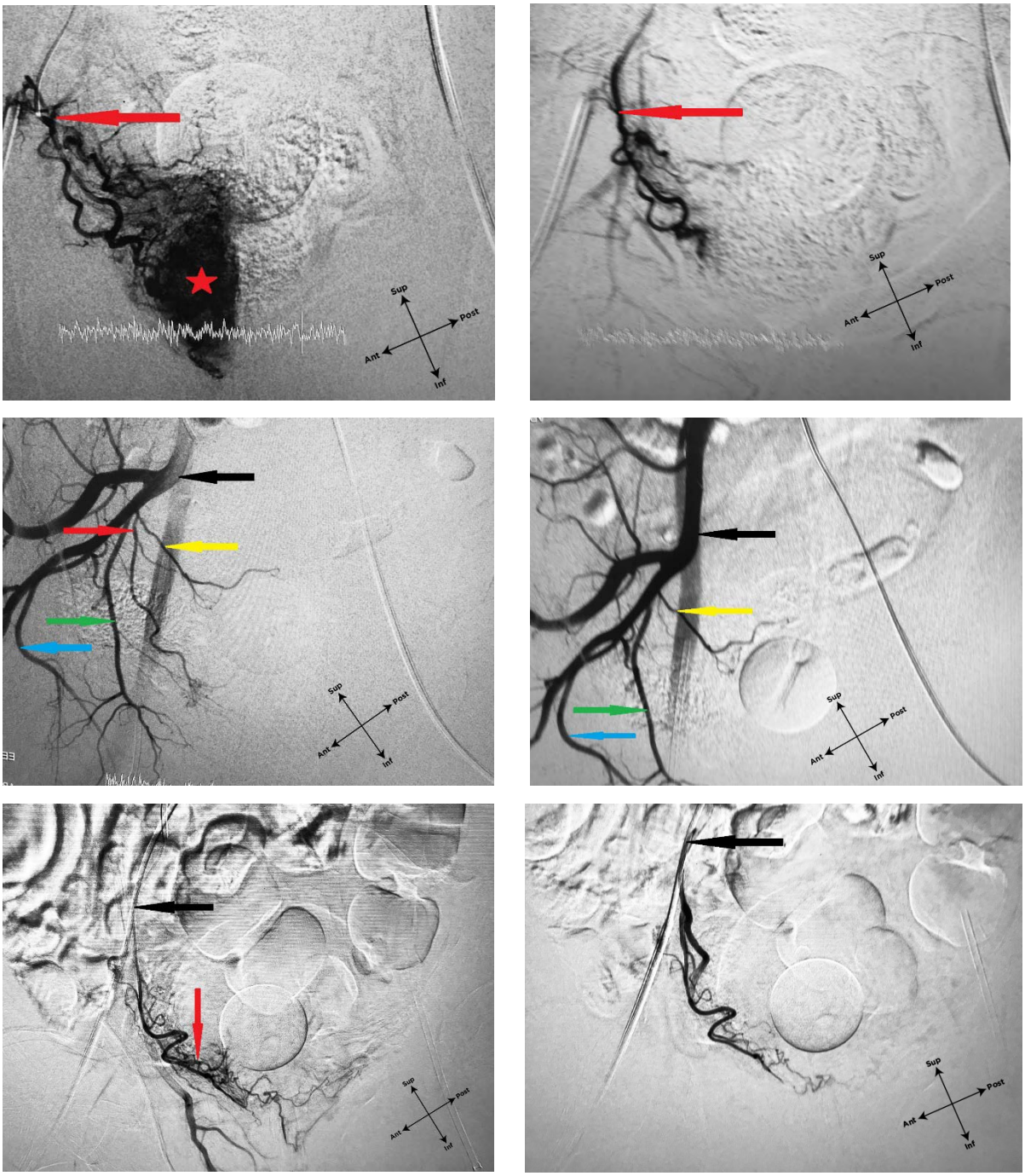

Fig. 2.- Digital subtraction angiography images demonstrating different origins of right prostatic arteries before and after embolization. In all images Black arrow points to the internal iliac artery or the microcatheter inside it. Yellow arrow points to the vesical artery, Green artery points to the obturator artery. Blue artery points to the internal pudendal artery. Red arrow points to the prostatic artery. a) Pre-embolization blush (*) of prostatic artery. b) The same patient following embolization. c) Pre-embolization prostatic artery originating from vesical trunk. d) The same patient following embolization. e) Pre-embolization prostatic artery originating from internal iliac artery. f) The same patient following embolization.

The PA originated from the vesical artery in 60% of the cadaveric arm of the study and in 41.7 % of the radiological arm. These cadaveric results strongly correspond to those of Garcia-Monaco et al. (2014) who reported the vesical artery as the most common origin of the PA in 56.5% of cases. The similarity between the results along with the rarity of cadaveric studies highlights the important implication of the study.

On the other hand, the radiological findings strongly support our previous results (Basiouny et al., 2022). They also correspond to the findings of Carnevale et al. (2017), Du Pisanie et al. (2019), Enderlein et al. (2020) and Moschouris et al. (2023), who reported the superior vesical artery as the most common origin of the PA in 33.9%, 34.3%, 27.5% and 31% of cases respectively. The cumulative consideration of the vesical origin in

Table 3. Showing the mean and standard deviation (SD) of IPSS before the procedure and 3 and 6 months post-embolization in all patients (N = 54)

IPSS Before		IPSS after 3 months		IPSS after 6 months		ANOVA	P value
Mean	SD	Mean	SD	Mean	SD		
24.53	2.91	16.31	2.57	11.56	2.83	252.03	0.0001

Table 4. Multiple comparison between IPSS before the procedure, 3 months, and 6 months post-procedure in all patients (N = 54)

Groups		P value	Lower bound of 95% CI	Upper bound of 95% CI
IPSS Before	IPSS after 3 months	0.0001	7.0653	9.3792
IPSS Before	IPSS after 6 months	0.0001	11.8208	14.1347
IPSS after 3 months	IPSS after 6 months	0.0001	3.5986	5.9125

Table 5. Mean and standard deviation of IPSS scores before, and at 3 and 6 months after the procedure, according to the origin of the PA (symmetrical bilateral cases only, N = 45)

IPSS	Vesical A (N = 18 = 40%)		Obturator A (N = 11 = 24.5%)		IPA (N = 10 = 22.2%)		IIA (N = 6 = 13.3%)		ANOVA	P value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Before	24.389	3.16	24.818	2.44	23.700	3.09	25.833	2.79	0.707	0.553
after 3 months	16.500	2.90	16.182	2.14	15.400	2.80	17.500	1.64	0.885	0.457
after 6 months	11.944	3.06	11.182	2.52	10.400	2.59	13.000	2.83	1.275	0.296

No statistically significant difference between the groups

Table 6. Mean and standard deviation (SD) of IPSS scores before, and at 3 and 6 months after the procedure, according to the age groups (N = 54)

IPSS	50-60 (N = 16 = 29.6%)		60-70 (N = 26 = 48.2%)		Above 70 (N = 12 = 22.2 %)		ANOVA	P value
	Mean	SD	Mean	SD	Mean	SD		
Before	24.29	3.07	25.40	2.62	23.27	2.94	2.062	0.140
after 3 months	15.71	2.73	17.35	2.01	16.18	2.75	3.424	0.132
after 6 months	11.07	3.27	12.45	2.61	10.55	2.34	1.986	0.150

No statistically significant difference between the groups

the present work may contribute to the higher levels observed. Conversely, variability in reported prevalence has been described in other reviews. Some studies have reported a higher frequency of origins from the internal pudendal artery or from a common trunk with superior vesical artery (Xuan et al., 2019; Șerbanoiu et al., 2023). These discrepancies are likely related to differences in study design, imaging technique and classification criteria, rather than true inconsistencies. Importantly, such studies primarily address overall clinical efficacy of prostate artery embolization, and do not specifically analyze the impact of arterial origin variability on clinical outcomes.

The present study was conducted on 54 patients, all over 50 years old, diagnosed with BPH and presenting with an IPSS score of 19 or higher. All the patients demonstrated improvement in IPSS score 3 and 6 months following the procedure. The mean IPSS score of the patients dropped from 24.53 before the procedure to 16.31 at three months and 11.56 six months after the procedure. The study revealed a highly significant difference as regards the IPSS progress, indicating a high treatment efficacy. These findings confidently confirm the suitability of this procedure for the treatment of BPH.

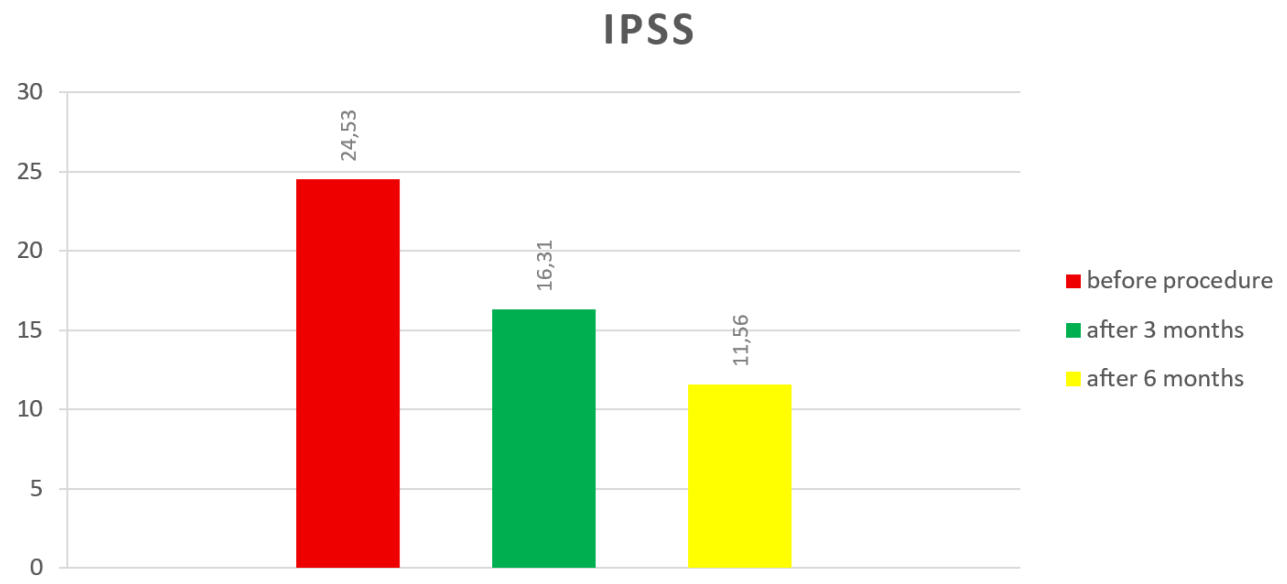

Fig. 3.- A chart illustrating the progression of IPSS scores before, and at 3 and 6 months after the procedure.

Recent meta-analyses and large clinical series have demonstrated that prostate artery embolization (PAE) results in significant improvement in IPSS and quality of life in patients with BPH, supporting its role as an effective, minimally invasive treatment option (Wang et al., 2018). Although comparative analyses have shown that certain functional outcomes, such as maximum urinary flow rate and prostate volume reduction, may be more pronounced following transurethral resection of the prostate (Xu et al., 2021), these studies primarily evaluate overall clinical efficacy and do not address the potential influence of anatomical variations in the origin of the prostatic artery. In this context, the present study adds specific anatomical insight by demonstrating that clinical improvement, as reflected by IPSS reduction, is achieved irrespective of the arterial origin pattern.

Neither the patient's age nor the origin of his PA affected the outcomes of the study. There was no statistically significant difference between patient groups when stratified by age. Although some studies have reported an inverse relationship between age and the success of the procedure (Bilhim et al., 2016), this was attributed later by the same author to arterial sclerosis and impaired bladder physiology (Bilhim, 2023). Enderlein et al. (2020) found that arterial tortuosity increases with age, resulting in longer procedure times and technical difficulties. The findings of the present work are consistent with this explanation. On the other hand, Loffroy et al. (2024) and Zorzi et al. (2025) denied the effect of the age as an influencing factor of IPSS improvement. Overall, it seems that age may influence the technical aspects of the procedure rather than its results.

In the present work, we examined both cadaveric and clinical findings as concerning the PA origin; we also monitored IPSS scores in order to establish a robust conclusion regarding the efficacy of PA embolization as a therapeutic procedure. However, the modest sample size —particularly in the cadaveric arm, where ethical considerations limited its use— and the single center design were obstacles that should be addressed in future work.

CONCLUSION

We conclude that the PA exhibits variable origins among the population, with the vesical arteries being the most common source. We also conclude that PA embolization is an effective therapeutic management of BPH, regardless of the patient's age or PA origin.

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AUTHORS CONTRIBUTION

Conceptualization, Ahmed F. AlDomairy, Gamal-el-

dine M. Niazi and Radwa M. Elsabban; Methodology, Gamal-eldine M. Niazi; Validation, Gamal-eldine M. Niazi; Data Curation, Ahmed F. AlDomairy and Radwa M. Elsabban; Writing – Original Draft Preparation, Radwa M. Elsabban Ahmed F. AlDomairy; Writing – Review & Editing, Ahmed F. AlDomairy; Supervision and Project Administration, Ahmed F. AlDomairy. All authors shared the literature search and revision, commented on previous versions of the manuscript and approved the final manuscript. They all agree to be personally accountable for their own contribution and for the accuracy and integrity of all parts of the work.

Institutional review board statement and compliance with ethical standards

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of October 6 University (protocol code O6U-ERC-0055).

Consents and privacy rights

A written informed consent was obtained from the patients included in this study. The privacy rights of the subjects were preserved.

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