Prostatic Artery Embolization (PAE) As Treatment for Lower Urinary Tract Obstruction Due To Benign Prostatic Hyperplasia: An Update of the Literature

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ABSTRACT
Prostate artery embolization (PAE) as treatment for lower urinary tract symptoms due to benign prostatic hyperplasia (BPH) was first undertaken in 2000 and since then utilization of PAE for the treatment of symptomatic BPH associated with failure of medical therapy or patients not being fit to undergo general anaesthesia or spinal anaesthesia for surgical treatment of the prostate gland has continued to be undertaken by well trained interventional radiologists in various well equipped interventional radiology units globally especially in the developed countries. PAE is a technically demanding procedure which is only undertaken by well trained interventional radiologists. PAE is undertaken under radiology imaging control via the left or right femoral artery or the radial artery under local anaesthesia. Super-selective catheterization of the small prostatic artery is undertaken with the use of fine microcatheters that traverse the pelvic arteries / internal pudendal arteries. The PAE procedure does involve introduction of microparticles to completely block the prostatic arteries. The embolization agents include polyvinyl alcohol (PVA) and other synthetic materials including microspheres. Successful PAE does lead to necrosis and shrinkage of the prostate gland. With regard to the technical details of PAE, the interventional radiologist does obtain access into the arterial system by piercing the femoral artery or the radial artery under radiology imaging control including ultrasound scan with utilization of a trocar which is hollow. A guide-wire is threaded through the trocar and trocar is then removed. A cannula is passed over the guide-wire and once the cannula is in place the guide-wire is removed. The cannula does allow a sheath to be inserted into the artery. Contrast material is injected through the sheath under radiology imaging / fluoroscopic control which does allow the anatomy of the pelvic blood vessels to be illustrated including the anatomy of the internal pudendal artery as well as if the anatomy is normal or there is a variation in the anatomy of the pelvic vessels including whether or not there is tortuosity of the pelvic vessels or atherosclerosis of the vessels. The contrast angiography is utilized to guide the interventional radiologist to identify the prostate artery in order to advance the catheter to the ostium of the prostate artery. The anatomy of the pelvic vessels does vary which is well known by all interventional radiologists. Successful PAE does refer to complete bilateral embolization of the prostatic arteries but at times the radiologist is only able to undertake unilateral embolization of a prostatic artery due to a variant anatomy of the pelvic vessel or tortuosity of the vessel or atherosclerosis. Over the past 18 years various case reports, case series, and studies of PAE either alone or in comparison with trans-urethral resection of the prostate have been reported in various journals. These publications have mostly shown that PAE is safe and efficacious in improving upon the IPSS, QoL, Q-max, Post -void residual urine volume, as well as reduction in the volume of the prostate. Some of the studies have shown almost equivalent in the IPSS improvement in comparison with the IPSS improvement pursuant to TURP. Nevertheless, some of the reported improvements in other functional outcomes have not been as good as that obtained following TURP. Additionally the studies had been reported with short and medium term-follow-up only hence generally one cannot confidently state what the overall long-term outcome of PAE would be. Nevertheless, PAE has been associated with minor complications mainly and not with major complications including major bleeding. TURP tends to be associated with higher incidence of retrograde ejaculation and erectile dysfunction in comparison with PAE in which the sexual function tends to remain stable. PAE tends to be associated with retention of urine / long period of urethral catheterization in comparison with TURP. The overall cost of PAE tends to be much cheaper in comparison with TURP because of the fact that PAE tends to be undertaken as an outpatient procedure without any hospitalization cost. Specific complications which could occur include non-target embolization that could lead to transient rectitis, or penile ulcer, urinary tract infection, and dysuria. PAE may be associated with pelvic and urethral pain of more than 1 to 3 days but PAE is not associated with dilutional hyponatraemia which occasionally occurs following TURP. There is need for more studies to be undertaken on PAE and to be reported with long-term follow-up to enable a consensus opinion to be made about the long term outcome of PAE. Meanwhile PAE could be undertaken on individuals who have failed medical therapy who are not fit to undergo surgery or who do not want to undergo surgery.
INTRODUCTION

Benign prostatic hyperplasia is said to be one of the commonest diseases that afflict men and it often tends to be associated with bladder outlet obstruction and lower urinary tract symptoms. It has been stated that the incidence of benign prostatic hyperplasia in men who are aged between 50 years and 60 years is 50% and the incidence of BPH tends to rise with increasing age [1-2] It has also been stated that the treatment of BPH does incur a substantial economic burden with estimated annual costs of up to 4 billion United States Dollars, or 3.01 billion United Kingdom pounds, or 3.45 billion Euros in within the United States of America 2006, as well as the mean annual treatment costs of 858 Euros per each patient in Europe in 2003 [3-4] It has been iterated that because of the demographic shift towards an elderly population, the costs that arise from lower urinary tract symptoms as a result of benign prostatic hyperplasia would likely increase substantially with progression of time. [1] It has been stated that if conservative treatment for BPH fails or if patients develop complications related to BPH, then surgical treatment for BPH would be recommended and that within the United States of America more than 100,000 men do undergo surgical treatment annually for BPH. [5] Additionally it has been stated that trans-urethral resection of prostate (TURP) has remained the gold standard treatment for BPH for majority of patients. [6-7] Nevertheless, it has been iterated that TURP tends to be associated with high morbidity [8-9] as well as that 40% of individuals who have undergone TURP for BPH do tend to have residual lower urinary tract symptoms which tends to require medical treatment within a period of 5 years pursuant to their surgical treatment. [10] In view of the aforementioned drawbacks has necessitated the search for less invasive forms of treatment for BPH.

In 2000, utilization of PAE as treatment for LUTS due to BPH which had improved the symptoms was reported. [11] Since then reports of Utilization of PAE as treatment of LUTs due to BPH have been reported to be associated with improvement in symptoms, and to be associated with favourable side effect profile as well as lower treatment costs in comparison with TURP. [12-13] Some of the reports of the efficacy of PAE in the treatment had been criticised in that they did not have controlled groups of patients but 3 published papers had included control groups that had received established surgical treatment but the results had been controversial. [14-16]

Some people are of the opinion that PAE as treatment for LUTS due to BPH should remain experimental in that the results of reported studies are not strong enough for PAE to be considered good enough to be considered a gold standard or a very suitable alternative treatment for LUTS due to BPH to be adopted globally as standard treatment. [12, 17]

The rationale of embolization of prostatic artery as treatment for lower urinary tract symptoms to benign prostatic hyperplasia is stated to generally include two parts (a) shrinkage of the enlarged prostate gland as a result of Prostatic artery embolization (PAE) induced ischaemic infarction and (b) potential effects to relax the increased prostatic smooth muscle tone by reducing the number and density of alpha 1 adrenergic receptor in the stroma of the prostate gland. [18] The ensuing extensive review and update of the literature on utilization of PAE in the treatment of LUTS due to BPH is divided into two parts (A) Overview which has discussed generalised aspects of LUTS and BPH and (B) Miscellaneous narrations and discussions related to some case reports, case series, and studies related to utilization of PAE in the treatment of symptomatic BPH or complications ensuing BPH.
METHODS
Internet databases were searched including Google; Google Scholar; Yahoo, and PUBMED. The search words used included: Embolization of prostate artery for benign prostatic hyperplasia; Prostatic Artery Embolization for benign prostatic hyperplasia; PAE for BPH. Lower urinary tract symptoms; Benign prostatic hyperplasia. Fifty two references were identified which were used to write the article that has been divided into two parts (A) Overview, and (B) Miscellaneous narrations and discussions related to some case reports, case series, and studies related to utilization of PAE in the treatment of symptomatic BPH or complications ensuing BPH.

OVERVIEW [19]
Definition / General Comments
• Benign prostatic hypertrophy (BPH) is a terminology which has been coined for an increase in the epithelial and stromal cell number called hyperplasia in the peri-urethral area of the prostate gland
• Benign prostatic hyperplasia has also been referred to as benign prostatic hypertrophy (BPH)
• It has been stated that BPH tends to be present in 20% of men who are aged 40 years, in 50% of men who are aged 50 years, and in 70% of men who are aged 60 years.
• It has been stated that there is no correlation between the histology features of BPH and symptoms and that 50% of individuals who have histological features have symptoms but the rest of individuals have enlarged prostate only without any symptoms.
• The symptoms associated with BPH do not tend to correlate directly with the actual size of the prostate gland in that some people with mildly enlarged prostate gland may have more severe symptoms in comparison with other individuals who have larger-sized prostate glands.
• It has been documented that the incidence of BPH is higher in individuals of African Americans.

Pathophysiology [19]
Some of the factors related to the pathophysiology of BPH have been summarized as follows:
• The development of BPH does require intact testes.
• Testosterone and dihydrotestosterone which is ten times more potent than testosterone bind nuclear androgen receptors within stromal and epithelial cells which cause activation of growth factor.
• Stromal cells do produce 5 alpha reductase which converts testosterone to dihydrotestosterone.
• Oestradiol which tends to be increased in aging men, could also increase androgen receptors.

Presentation
Many individuals with enlarged prostate glands due to BPH may be asymptomatic but many individuals may present with the following manifestations:
• Poor urinary flow / weak stream of urine
• Hesitancy
• Intermittent / interrupted flow,
• Post-micturition dribbling of urine
• Sensation of incomplete emptying of urine from the urinary bladder.
• Urinary frequency
• Urinary urgency
• Supra-pubic pain preceding voiding
• Urinary urge incontinence
• Palpable supra-pubic mass
• Supra-pubic pain and urge to void without being able to void and clinically being found to be in acute retention of urine.
• Chronic retention with over-flow of urine.
• Haematuria
• Urinary tract infection symptoms of dysuria, and fever.

Clinical Examination findings
• The general and systematic examinations may be normal.
• There may be a palpable supra-pubic mass or a percussion of dullness in the supra-pubic region due to retention of urine.
• Digital examination finding of an enlarged prostate that feels clinically benign or firm and nodular.
• Urinary bladder scanning may show significant post-void residual urine and at times an intravesical protruding prostate could be seen in the images of the scan.
• If there is an associated urinary tract infection there could be pyrexia.
Investigations

Urine
- Urinalysis urine microscopy and urine culture and sensitivity tend to be undertaken as part of the general assessment of patients who have LUTS but the results would not be diagnostic of BPH but if there is evidence of urinary tract infection the infection would be treated to improve upon the general condition of the patient.

Haematology
- Full blood count, and coagulation screen are general screening tests that are carried out as part of the screening assessment of patients who have LUTS and the results would generally tend to be normal but if there is any urinary tract infection the white blood cell count could be raised and if the infection is appropriately treated the white blood cell count would return to normal. Also if there is anaemia it would be investigated appropriately and treated. If there is haematuria associated with the BPH this could also show evidence of anaemia. Coagulation screen is important because some patients who have LUTS and BPH may be on anticoagulants or medications that could affect their coagulation screen because of their co-morbidities and the coagulation screen status of the patients would be helpful in the planning and timing of any surgical procedures that are planned for the patients.

Biochemistry
- Serum urea and electrolytes, liver function tests, blood glucose, serum prostate-specific antigen (PSA) are general tests that tend to be undertaken as part of the general assessments of patients who have LUTS and BPH. The results would tend to be normal in most cases but if any of the results are abnormal the cause or causes would be investigated appropriately and treated. If the age-specific serum PSA is raised then it would be investigated appropriately to exclude carcinoma of the prostate gland.

Radiology
Post-Micturition Urinary Bladder Scan
- Post void residual urine volume is a common basic investigation that is undertaken to ascertain in the patient has emptied his urinary bladder completely or if there is a residual urine volume and this screening test tends to be undertaken pursuant to urine flow rate estimate in the initial assessment as well as follow-up assessments to ascertain if the voiding and emptying functions have improved with the initial medical treatment or not and if the urine post-void residual volume is increasing plus or minus the urine flow rate is diminishing surgical treatment can be discussed and subsequently undertaken.
- A residual volume of greater than 200 millilitres in an individual who has been on medical treatment for LUTS due to BPH tends to be an indication for a surgical treatment option.

Ultrasound scan of the urinary tract, and pelvis.
- Patients who have LUTS tend to undergo ultrasound scan of abdomen, renal tract and pelvis and this would indicate the size and ultrasound scan features of the prostate, the ultrasound scan features of the urinary bladder as to whether or not there is a lesion / stone / urothelial lesion within the urinary bladder as well as if there is a forgotten ureteric stent the ultrasound scan would show it. Additionally, if there is thickening of the wall of the urinary bladder or diverticulum of the urinary bladder or hydronephrosis the ultrasound scan would show it including if there is intravesical protrusion of the prostate.
- Individuals who have developed retention of urine due to BPH with failure of urethral catheterization and who have had a lower abdominal laparotomy incision would tend to require ultrasound scan-guided insertion of supra-pubic catheter.

CT scan of renal tract, abdomen and pelvis
- CT scan does not tend to be undertaken as part of the general screening of individual men who have LUTS due to BPH but when digital rectal examination shows an abnormal area in the prostate with or without raised serum PSA levels, CT scan of the pelvis would tend to be undertaken to study the features of the prostate as part of the initial prostate assessment for the size and features of the prostate gland.
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its surrounding areas in the pelvis and this tends to be linked with the undertaking of trans-rectal ultrasound scan guided biopsy of the prostate to exclude carcinoma of the prostate gland.

- In some cases of BPH, the MRI scan of pelvis could confirm presence of calcification / corpora amylaceae or chronic prostatitis when the digital rectal examination shows a hard mass in the prostate without a raised serum PSA.
- Sometimes if a trans-rectal ultrasound guided biopsy of the prostate has shown histology examination features of a benign prostate but the serum PSA is still rising MRI scan of pelvis and prostate tends to be undertaken to ascertain if there are any abnormal areas that may need to be targeted for further biopsy by means of template biopsies and targeted biopsy in areas of the prostate gland that are not accessible to ultrasound-guided biopsy of the prostate.

Flexible cystoscopy
- Flexible cystoscopy tends to be undertaken as part of the investigation of LUTS to ascertain if the LUTS that has been provisionally diagnosed to be due to BPH is correct and to investigate whether or not the individual has a urethral stenosis / stricture or a lesion within the urinary bladder that is mimicking BPH.

Urodynamics
- Urodynamics studies undertaken when there are mixed urinary tract symptoms would confirm the diagnosis of the cause of LUTS
- A high detrusor-pressure with a low or poor Q-max in a stable bladder would confirm lower urinary tract obstruction.
- Urodynamics assessment would also indicate if there is urinary bladder instability during the filling phase of the cystometry as well as if there is any urge incontinence.
- The urinary bladder capacity as well as cystometry features of the bladder would be determined by the urodynamics tests including atonic bladder.
- If an individual has incontinence following TURP, urodynamics would ascertain whether the incontinence is pure stress incontinence or due to vertical instability of the urinary bladder when the individual stands up (vertical instability).

Uroflometry
When the urine flow rate is less than 10 millilitres per second with an obstructed interrupted type of flow this tends to be an indication for surgical treatment for BPH after excluding an atonic bladder which tends also to be associated with a large capacity bladder but in a straight forward LUTS due to bladder outlet obstruction the bladder tends to be normal.

Treatment
Many individuals who have mild lower urinary tract symptoms due to BPH can be observed but if there is evidence of worsening of symptoms could be treated by means of medical therapy or surgical treatment depending upon their follow-up status. Nevertheless, treatment that is aimed at improving symptoms of BPH / their complications includes:

Medical treatment

Alpha blockers
Some of the types of alpha blockers that have been used in the treatment of BPH have included:
- Non-selective alpha blocker phenoxymenzamine which tends to be effective with regard to symptom control but it tends to be associated with a high side-effect profile and for this reason it does not tend to be prescribed routinely to improve lower urinary tract symptoms due to BPH.
- Alpha1 blockers including: Prazosin, Alfuzosin (Xatral), and Indoramin.
- Long-acting Alpha1 blockers Terazosin, Doxazosin, Alfuzosin SR.
- Alpha1a androgen receptor blocker Tamsulosin.
- Quite commonly the two most frequently used alpha blockers in the treatment of LUTs include Tamsulosin and Alfuzosin.
- Some of the side effects associated with utilization of alpha blockers in some patients include asthenia / weakness, dizziness, headache, postural hypotension, and retrograde ejaculation in a minority of patients and when these side effects are noted some patients stop taking their medication which tends to be changed to a different form of treatment.

Five Alpha reductase inhibitors
Some of the five alpha-reductase inhibitors that tend to be used include
- Finasteride (Proscar)
- Avodart (Dutasteride)

Five alpha reductase inhibitors tend to be associated with loss of libido, impotence, and reduction in the volume of the ejaculate in some patients.
Combined Medications of Alpha blockers and Alpha reductase inhibitors
- A combination of alpha blocker and alpha reductase inhibitors have been used in some cases of LUTS associated with large sized prostate glands.

Anti-cholinergic medications
- When a patient has significant irritating urinary bladder symptoms associated with BPH and there is evidence of complete urinary bladder emptying or urinary bladder emptying with little residual urine volume and flexible cystoscopy does not show any evidence of a urothelial lesion or calculus or foreign body within the urinary bladder then anti-cholinergic an anti-cholinergic medication can be used to improve the symptoms of urinary urgency and urge incontinence. Some of these possible medications include oxybutynin, tolterodine/detrusitol, tropium chloride, flavoxate, and Vesicare.

- A side effect of anti-cholinergic medications include dryness of the mouth and constipation and on very rare occasions the individual may present with retention of urine which would require urethral catheterization and stopping of the anti-cholinergic medication but this is extremely rare.

Phototherapy
Quite often globally especially in Europe, Africa and North America before some patients are seen by urologists because of LUTs due to BPH, they have been taking or started taking phytotherapeutic medicaments as alternative drug therapy. Some of these medications are derived from plants and include:

- The African Plum (Pygeum Africanum)
- Purple cone flower (Echinacea purpurea),
- South African Star Grass (Hipoxis rooperi).
- Saw Palmetto berry (Seronoa Repens, Permixon).

It has been stated that Saw Palmetto berry does contain an anti-inflammatory, anti-proliferative, oestrogenic drug which does have 5 alpha-reductase inhibitory activity and that Saw it was derived from the American dwarf palm. [20] It has also been stated that Saw Palmetto was compared with finasteride in a large double-blind, randomized trial, and in which 40% equivalent reductions in symptom score were found in both Saw Palmetto and finasteride over a 6-months period. [chap4 20] A meta-analysis which had included 18 randomized controlled trials of almost 3000 men did indicate that Seronoa repens does produce similar improvements in symptoms and urine flow rates to those that had been produced by finasteride. [21]

It has been iterated that South African star grass (Hipoxis rooperi which is marketed as Harzol does contain beta-sitosterol, that could induce apoptosis in prostate stromal cells, by inducing raised levels of TGF-ß1 and that in a double blind, randomized controlled trial, symptom had been 5 points over that obtained with placebo. [4,20].

It had also been stated that with regard to other agents for example Urtica dioica (stinging nettle; the African plum) the studies had not been undertaken with placebo control and the studies had lacked sufficient statistical power in order to prove conclusively that they work effectively. [22]

Surgical treatment
Open Retro pubic prostatectomy
- Retropubic prostatectomy tends to be undertaken for very large prostates but in developing countries where some of the surgeons have not been trained to undertake TURPS at times open prostatectomy including retropubic prostatectomy tend to be undertaken. In some developing countries even if the surgeon can undertake TURP lack of resectoscopes may make the individual surgeon undertake open prostatectomy including retropubic prostatectomy.

- Undertaking of retropubic prostatectomy requires either general anaesthesia or spinal anaesthesia.

- Some surgeons keep their patients in hospital for 7 days to 10 days following retropubic prostatectomy and discharge the patients after removal of the urethral catheter. Other surgeons discharge patients after 2 days to go home with their catheters after removal of their drains and to come back for trial without catheter after 10 days.

- Complications that could be associated with retropubic prostatectomy include bleeding, infection, deep vein thrombosis, retrograde ejaculation, incontinence, impotence, would infection.

Open trans-vesical prostatectomy.
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- Trans-vesical prostatectomy tends to be undertaken for very large prostates but in developing countries where some of the surgeons have not been trained to undertake TURPS at times open prostatectomy including retropubic prostatectomy tend to be undertaken. In some developing countries even if the surgeon can undertake TURP lack of resectoscopes may make the individual surgeon undertake open prostatectomy including retropubic prostatectomy.
  - Undertaking of trans-vesical prostatectomy requires either general anaesthesia or spinal anaesthesia.
  - Some surgeons keep their patients in hospital for 7 days to 10 days following trans-vesical prostatectomy and discharge the patients after removal of the urethral catheter. Other surgeons discharge patients after 2 days to go home with their catheters after removal of their drains and to come back for trial without catheter after 10 days.
  - Complications that could be associated with trans-vesical prostatectomy include bleeding, infection, deep vein thrombosis, retrograde ejaculation, incontinence, impotence, would infection.

Trans-urethral incision of prostate, / Bladder neck incision
- Bladder neck incision / trans-urethral incision of prostate tends to be undertaken for some LUTS associated with slightly enlarged prostates with high bladder neck and this tend to improve the flow of urine and it also tends to be associated with less bleeding or minimal bleeding in comparison with TURP.
- Undertaking of Bladder neck incision / Trans-urethral incision of prostate requires either general anaesthesia or spinal anaesthesia.

Trans-urethral resection of prostate.
- TURP has been the standard operation for majority of cases of lower urinary tract obstruction due to BPH.
  - Generally TURP tends to be undertaken under general anaesthesia or spinal anaesthesia.
  - Some of the complications associated with TURP include: bleeding, infection, deep vein thrombosis, retrograde ejaculation, impotence, incontinence, Trans-urethral resection of prostate syndrome (TURP syndrome) which is rare these days but needs to be matched for carefully.
  - Patients who undergo TURP tend to be discharged home between 24 and 48 hours but majority of the patients tend to be discharged after 2 days.

Uro-lift operation
- Urolift procedure is another form of surgical treatment for selected cases of prostates and is being undertaken by only few urological surgeons globally.

Trans-urethral needle ablation (TUNA) of the prostate gland.
- Improvements in symptom score and urine flow-rate tend to be moderate and some of the side effects following TUNA include bleeding, infection, deep vein thrombosis, retrograde ejaculation, impotence, incontinence, Trans-urethral resection of prostate syndrome (TURP syndrome) which is rare these days but needs to be matched for carefully.

Trans-urethral microwave therapy (TUMT)
- Some of the sexual side effects that ensue TUMT including impotence, retrograde ejaculation tend to be less common in comparison with after TURP, but the period of urethral catheterization tends to be longer in comparison with TURP, and urinary tract infections and irritative urinary symptoms tend to be commoner. [20, 24]

High-intensity focussed ultrasound (HIFU)
- With regard to HIFU treatment of BPH a trans-rectal probe tends to be used as well as a general anaesthesia or heavy sedation during the treatment. [20]
- Anterior commissurotomy (this procedure was briefly undertaken previously but is not being undertaken anymore)

Intermittent self-urethral catheterization.
- People who are not suitable for surgery or do not want to undergo surgical operation who have good manual dexterity that are not emptying their urinary bladder properly can be taught to undertake intermittent self-catheterization to empty their urinary bladder and avoid having a long-term urethral catheter.

Long-term urethral catheterization
- Individuals who are at risk or not fit to undergo surgical operation may be offered long-term urethral catheterization in which the urethral catheters tend to be changed after every 3 months.
• Long term urethral catheters tend at times to be associated with bleeding, urinary tract infections, catheter blockages and at times developments of vesical calculi which tend to obstruct the catheters and the stones would need to be removed. For this reason follow-up ultrasound scans need to be undertaken at regular scheduled times of between once every 6 to 12 months in order to identify any stones that develop in the urinary bladder early. Also regular bladder wash outs could remove any small calculi that form within the bladder before they enlarge.
• If a urethral catheter is in situ for more than 10 years the possibility of urothelial carcinoma developing in the urinary bladder must be borne in mind so that surveillance flexible cystoscopy is undertaken at yearly intervals after an individual has had a catheter in situ for many years.

Suprapubic catheter insertion
• Suprapubic catheter insertion can be undertaken for short term if the patient is fit to undergo surgical operation following which the supra-pubic catheter is removed.
• Suprapubic catheter tend to be undertaken when long-term catheter has been associated with erosion of the urethra or there has been difficulty in changing the long-term urethral catheter for anatomical reasons.
• Individuals that are sexually active would prefer to have long-term suprapubic catheter.
• Long term suprapubic catheters that are changed at 3 months intervals can also be complicated by suprapubic catheter falling out, bleeding, catheter blockages, urinary tract infections, development of vesical calculi as well as patients who have had long-term catheters for long periods of time of over 10 years could develop urothelial carcinomas of the urinary bladder due to chronic infection.

Urethral stents
Some patients who are not fit to undergo surgery for TURP may undergo insertion of prostatic stents as an alternative form of treatment but this procedure tends to be undertaken occasionally.

Prostate Artery Embolization (PAE)
• Prostatic Artery Embolization has emerged as an alternative form of treatment for lower urinary tract symptoms due to BPH and it tends to be undertaken under local anaesthesia and thus avoids general anaesthesia as well as spinal anaesthesia.
• Majority of cases of PAE tend to be undertaken as outpatient procedures or day case procedures.
• The outcomes of most cases of PAE tend to be associated with improvements in most parameters of LUTS that could be similar to the improvements of symptoms of some TURPS; nevertheless, TURP has been associated with better flows in comparison with PAE even though there has also been satisfactory improvements related to PAE in most reported cases.
• Patients who are not fit to undergo surgical operations for TURP or open prostatectomy can undergo PAE safely.
• Most reports of PAE have not reported long term outcomes of the procedure even though the short-term and medium term outcomes have been good.
• The incidence of retrograde ejaculation, impotence and incontinence following PAE have tended to be good or low.
• Minor complications following PAE do occur and need to be looked for / avoided by undertaking careful PAE by a well-trained interventional radiologist and some of these complications include non-target embolization resulting in rectitis and blood in urine that tend to be transient, penile ulceration, dysuria due to embolization of blood vessel to part of the urethra, and embolization of blood supply to urinary bladder base.
• PAE has not clearly been shown to be associated with a very long-term follow-up outcome so for now PAE could serve the purpose as another form of treatment following failure of medical therapy in individuals who want to remain sexually active and those patients who are not fit to undergo general anaesthesia or spinal anaesthesia.
• Undertaking of PAE could be difficult in some situations due to atherosclerosis of the pelvic vessels, anatomical variations of the pelvic vessels or tortuosity of the pelvic vessels; nevertheless for majority of cases utilization of careful selective angiongraphy of the internal pudendal artery and reinforced by careful computed tomography and magnetic resonance imaging scans a successful bilateral PAE or at least unilateral PAE could be undertaken without any untoward effects.
• Many more interventional radiologists need to be trained to undertake PAE for BPH and they should report their cases and case series with long term follow-up outcome to enable global acceptance of the PAE procedure as another gold standard alternative treatment for symptomatic BPH following failure of medical therapy for BPH.

Macroscopy Features
Gross examination of specimens of benign prostatic hyperplasia prostate gland obtained at prostatectomy would tend to show the following:

- Large, discrete, peri-urethral nodules.
- The mean size of open prostatectomy specimen tends to be about 100 grams [19] but larger and smaller glands have also been removed by the open surgical method.
- It has been iterated that benign prostatic hyperplasia specimens tend usually to be within the transitional and periurethral zones of the prostate gland and 5% tend to be found in the peripheral zone, even though the enlarged benign prostatic hyperplasia tissue could compress the outer peripheral zone of the prostate gland.
- Macroscopic examination of benign glandular prostatic hyperplasia tissue does reveal a yellow-pink, soft, tissue oozing prostatic fluids.
- Macroscopic examination of the stromal hyperplasia does reveal a grey and tough tissue.

Microscopy features

It has been stated that microscopic examination of specimens of benign prostatic hyperplasia tend to show the following features:

- Hyperplasia of glandular or stromal tissue with papillary buds, infoldings, as well as cysts.
- Features of associated squamous metaplasia and infarction could also be seen.
- The features of benign prostatic hyperplasia tend to begin around the urethra where the ejaculatory ducts enter the prostate in the transitional or peri-urethral zone.
- The basal cell layer tends to be continuous.
- The stromal changes in benign prostatic hyperplasia tend to include: increased smooth muscle, lymphocytes and ducts, which tend not to be associated with infectious process of prostatitis in majority of cases, and reduced elastic tissue.
- Variations in the microscopy features of benign prostatic hyperplasia include: sclerosing adenosis, fibroadenoma-like and phyllodes-like hyperplasia, leiomyoma-like nodules, fibromyxoid nodules in association with an infarct.

Immunohistochemistry features

It has been stated that immunohistochemistry staining for benign prostatic hyperplasia tends to show:

Positive staining for CD 10 [19, 25]

Differential Diagnosis

The symptoms of BPH are non-specific and tend to mimic symptoms of the ensuing conditions from which BPH must be excluded: [26]

- Cystitis.
- Prostatitis.
- Prostatodynia.
- Prostatic abscess.
- Overactive urinary bladder.
- Carcinoma of the urinary bladder.
- Foreign bodies within the urinary bladder including vesical calculus and ureteric stents.
- Urethral stricture ensuing trauma, previous surgery, or sexually transmitted diseases.
- Carcinoma of the prostate gland.
- Neurogenic urinary bladder.
- Pelvic floor dysfunction.

The differential diagnoses of BPH have been summated to include the following: [26]

- Carcinoma of the urinary bladder.
- Urinary bladder calculi.
- Trauma of the urinary bladder.
- Interstitial cystitis.
- Neurogenic bladder.
- Prostatitis.
- Radiation cystitis.
- Urethral strictures in men.
- Urinary tract infections in men.

Other differential diagnoses of LUTS and BPH include:

- Phimosis / External urethral meatus stenosis.
- Urethral diverticulum and calculus within the urethral diverticulum.
- Vesical diverticulum.
Miscellaneous Narrations and Discussions from Some Case Reports, Case Series and Studies Undertaken Related to Embolization of The Prostate Glands For Benign Prostatic Hyperplasia Associated Symptoms

Abt et al. [1] reported 103 patients who were 40 years old or older than 40 years with refractory lower urinary tract symptoms secondary to benign prostatic hyperplasia who were randomised between 11 February 2014 and 24th May 2017 that included 48 men and 51 men who had reached the primary end points at 12 weeks after PAE and TURP respectively. Abt et al. [1] reported that with regard to the interventions, PAE was undertaken with utilization of 250 to 500 micrometre microspheres under local anaesthesia versus utilization of monopolar TURP which was undertaken under spinal or general anaesthesia. The primary outcome of the study was change in the international prostate symptom score (IPSS) from baseline at 12 weeks pursuant to surgery; a difference of less than 3 points between treatments had been defined as non-inferiority for PAE and tested with a one sided t test. The secondary outcomes did include further questionnaires, functional measures, magnetic resonance imaging scan findings, adverse events, changes from baseline to 12 weeks were compared between the treatments with two sided tests for superiority. Abt et al. [1] summarized the results as follows:

- The mean reduction in IPSS from baseline to 12 weeks was -9.23 points after PAE and -10.77 points pursuant to TURP. Even though the difference was less than 3 points which was 1.54 points in favour of TURP with a 95% confidence interval of -1.45 to 4.52, noninferiority of PAE could not be illustrated with P = 0.17.
- None of the patient reported secondary outcomes did differ significantly between the treatments when they were tested for superiority; IPSS did not significantly differ with P = 0.31.
- At 12 weeks it was observed that PAE was less effective in comparison with TURP with regard to changes in maximum urine flow rates (Q-max) which was 5.19 versus 15.34 millilitres per second with a difference of 10.15 at a 95% Confidence Interval of -14.67 to – 5.63 with P < 0.001, post-void residual urine volume (-86.36 versus 199.98 millilitres; 113.62 (39.25 to 187.98); P = 0.003, prostate volume (-12.17 versus – 30.27 millilitres; 18.11 (10.11 to 26.10); P < 0.001, as well as des-obstructive effectiveness according to pressure flow studies which amounted to 56% versus 93% shift towards less obstructive category with a P value of P = 0.003. Fewer adverse events did develop pursuant to PAE in comparison with pursuant to TURP (36 events versus 70 events); P = 0.003.

Abt et al. [1] made the following conclusions:

- The improvements in lower urinary tract symptoms secondary to BPH seen at 12 weeks pursuant to PAE is close to that pursuant to TURP.
- PAE has tended to be associated with fewer complications in comparison with TURP but PAE does have disadvantages with regard to functional outcomes which should be taken into consideration when selecting patients for PAE.
- Further comparative study findings which include longer follow-up should be assessed before PAE could be considered as a routine treatment for symptomatic BPH.

Kurbatov et al. [27] did investigate the clinical benefits of prostate artery embolization (PAE) in patients whose prostate volume was equal to or greater than 80 cubic centimetres and whose Charlson comorbidity index (CCI) was equal to or greater than 2. And had been affected by benign prostatic obstruction (BPO) symptoms. Kurbatov et al. [27] summarized the methods of the study as follows:

- From January 2009 to January 2012, PAE had been undertaken on 88 consecutive patients who had been afflicted by benign prostatic obstruction (BPO) symptoms.
- The inclusion criteria included:
  - Symptomatic BPO that that was refractory to medical therapy.
  - International prostate symptom score (IPSS) of equal to or greater than 12.
  - Total prostate volume (TPV) of equal to or greater than 80 cubic centimetres.
  - Q max of less than 15 millilitres per second
  - And CCI equal to or greater than 2.
- The primary end points included the reduction of 7 points within the IPSS as well as the increase of Q-max.
- The secondary end points included:
  - Reduction of TPV
  - Post void residual (PVR) urine volume
  - Prostate specific antigen (PSA) level
  - The International Index of Erectile Function 5 Score
  - And the IPSS Quality of Life (QOL) Score.
- Follow-up assessments were undertaken at 3 months, 6 months, and 12 months.
Kurbatov et al. [27] summated the results as follows:

- The mean IPSS score at 1 year were significantly different with respect to the baseline score it was 10.40 versus 23.98 at P<0.05, and the mean Q-max was significantly higher at 1 year in comparison with baseline in that it was 16.89 millilitres / second versus 7.28 millilitres per second at P<0.05.
- When they took into consideration the secondary end points, they did observe significant variation with regard to PVR (18.38, versus 75.25 millilitres with P<0.05); TVP (71.20 cubic centimetres versus 129.31 cubic centimetres at P<0.05); and serum PSA level (2.12 versus 3.67 at P<0.05) at 1 year in comparison with at baseline.
- The mean IPSS-QoL did change significantly from the baseline to 1 year pursuant to to the PAE (5.10 versus 2.20 at P<0.05).
- No major or minor complications were identified.

Kurbatov et al. [27] concluded that they had illustrated the benefits of PAE with regard to the treatment of lower urinary tract symptoms and / or BPO by the reduction of IPSS, TVP, serum PSA level, PVR volume, and by the improvement in the urinary flow rate, and the quality of life (QoL) after 1 year with regard to patients who had prostate volume of equal to or greater than 80 cubic centimetres and CCI equal to or greater than 2.

Gao et al. [28] undertook a prospective randomized controlled trial which included 57 men who underwent prostate artery embolization (PAE), and 57 patients who had undergone trans-urethral resection of prostate (TURP) totalling 114 patients. They did compare the groups with regard to relevant adverse events as well as complications. They did assess functional results that had included improvement in the International Prostate Symptom Score (IPSS), quality of life (QoL) score, peak urine flow rate (Q-max also called maximum flow rate), post-voiding residual urine volume (also called post-micturition residual urine volume), serum prostate-specific antigen (PSA) level, as well as the prostate volume (PV), at 1 month-, 3 months-, 6 months-, 12 months-, and 24 months-follow-up between 20th January 2007 and 31st January 2012. They utilized Student t test, X² test, Fisher exact test, as well as repeated measures analysis for the analysis of results. Gao et al. [28] summarized the results as follows:

- The over-all technical success rates with regard to TURP and PAE were 100% and 94.7% respectively and the clinical failure rates for the aforementioned procedures were 3.9% and 9.4% respectively.
- The six functional results did show improvements pursuant to TURP as well as PAE at all of the post-operative follow-up assessments in comparison with the pre-operative values at P=0.001. Nevertheless, the TURP group did show greater values with regard to improvement the IPSS score, QoL score, peak urine flow (maximum urine flow) rate, and post-voiding residual urine volume (post-micturition residual urine volume) rate at 1 month-, and 3-months-follow-up, as well as greater reductions with regard to the serum PSA level, and prostate volume at the follow-up assessment times in comparison with the PAE group of patients at P<0.005.
- The PAE group of patients did show more over-all adverse events and complications at P=0.029, which were mostly related to acute retention of urine post-procedure which occurred in 25.9% of the patients, post-embolization syndrome which occurred in 11.1% of patients, and treatment failures of which 5.3% were due to technical failures and 9.4% had clinical failures.

Gao et al. [28] made the ensuing conclusions:

- Both procedures of TURP and PAE did result in significant improvements with regard to the treatment of benign prostatic hyperplasia (BPH).
- Nevertheless, the advantages of the PAE procedure should be weighed against the potential for technical and clinical failure with respect to a minority of patients.

It would be argued that based upon the knowledge that 11.1% of patients who underwent PAE developed post-embolization syndrome, utilization of peri-operative hydrocortisone or steroids pre-PAE and immediately post-PAE would abolish or minimize the post-embolization syndrome in the patients who undergo PAE procedures.

Pisco et al. [29] evaluated if prostatic arterial embolization (PAE) could be a feasible procedure to undertake as treatment for lower urinary tract symptoms associated with benign prostatic hyperplasia. Pisco et al. [29] reported fifteen patients whose ages had ranged between 62 years and 82 years with a mean age of 74.1 years who had symptomatic benign prostatic hyperplasia (BPH) following failure of medical therapy who had been selected for PAE with utilization of non-spherical 200 micrometres polyvinyl alcohol particles. The procedure was undertaken by a single femoral approach. Technical success was adjudged to have been achieved when selective prostatic arterial catheterisation and embolization was achieved on at least one side of the pelvis. Pisco et al. [29] summarized the results as follows:
PAE had been successful technically with regard to 14 out of the 15 patients which did amount to 93.3% of the patients.

The mean follow-up of the patients was 7.9 months but the follow-up of the patients did range between 3 months and 12 months.

The International Prostate Symptom score (IPSS) did decrease by a mean of 6.5 points at \( P = 0.005 \); The International Index of Erectile Function did increase by 1.7 points at \( P = 0.063 \); The peak (maximum) flow of urine did increase by 3.85 millilitres per second at \( P = 0.015 \).

There was a mean reduction of serum prostate-specific antigen of 2.27 ng / mL at \( P = 0.072 \).

The mean prostate volume had decreased by 26.5 millilitres at \( P = 0.0001 \) upon ultrasound scanning and by 28.9 millilitres upon magnetic resonance imaging scanning at \( P = 0.008 \).

One major complication did occur which involved a 1.5 centimetre square ischaemic area of urinary bladder wall and four clinical failures which amounted to 28.6%.

Pisco et al. [29] concluded that within their small group of patients, PAE was a feasible procedure, with the preliminary results, and the short-term follow-up results indicating a good symptom control without sexual dysfunction in suitable candidates as well as associated with a reduction in the volume of the prostate.

Bilhim et al. [30] undertook a study to compare the baseline data as well as clinical outcome between patients who have prostatic enlargement / benign prostatic hyperplasia (BE/BPH) who had undergone unilateral and bilateral prostatic arterial embolization (PAE) in order to relief lower urinary tract symptoms (LUTS). Bilhim et al. [30] compared 122 consecutive patients whose mean age was 66.7 years old that had unilateral versus bilateral PAE from March 2009 to December 2011. Selective PAE had been undertaken with 100- and 200- micro-metre non-spherical polyvinyl alcohol (PVA) particles by a unilateral femoral approach. Bilhim et al. [30] summarized the results as follows:

- Bilateral PAE was undertaken in 103 patients that constituted 84.4% of the patients that were allotted to group A of the patients. The remaining 19 patients that amounted to 15.6% of the patients did undergo unilateral PAE that were allotted to group B of patients.
- The mean follow-up time with regard to the patients that were allotted to group A was 6.7 months and the mean follow-up time with regard to the patients that were allotted to group B was 7.3 months.
- With regard to patients that were allotted to group A, the mean prostate volume, serum PSA, International Prostate Symptom Score / Quality of Life Score (IPSS/QoL), and post-void (post-micturition) residual (PVR/PMR) volume reduction, and peak (maximum) flow rate (Q-max) improvement were 19.4 milli-litres, 1.68 ng / mL, 11.8/2.0 points, 32.9 mL, and 3.9 milli-litres per second.
- With regard to the patients who had been allocated to group B, the mean prostate volume, serum PSA, International Prostate Symptom Score / Quality of Life Score (IPSS/QoL), and post-void (post-micturition) residual (PVR/PMR) volume reduction, and peak (maximum) flow rate (Q-max) improvement were 11.5 milli-litres, 1.98 ng / mL, 8.9/1.4 points, 35.8 millilitres, and 4.58 millilitres per second.
- Poor clinical outcome was found in 24.3% of patients in group A, and poor outcome was found in 47.4% of patients in group B at \( P = 0.04 \).

Bilhim et al. [30] made the following conclusions:

- PAE is a safe and effective technique which could induce 48% improvement with regard to IPSS score as well as reduction in prostate volume of 19% with good clinical outcome in up to 75% of patients that have been treated for lower urinary tract symptoms to enlarged prostate / benign prostatic hyperplasia.
- Bilateral PAE would appear to be associated with better clinical results; nevertheless, up to 50% of patients following unilateral PAE could have a good clinical outcome.

Carnevale et al. [16] compared the clinical and urodynamics results of trans-urethral resection of prostate (TURP) with original and PErFecTED prostate artery embolization (PAE) methods for benign prostatic hyperplasia. Carnevale et al. [16] did prospectively randomised 30 patients to receive trans-urethral resection of prostate (TURP) or original PAE (oPAE) and they did compare them to a cohort of patients who were treated by PErFecTED PAE, with a minimum of one year follow-up. The patients were assessed with regard to urodynamics parameters, prostate volume, International Prostate Symptom Score (IPSS), as well as Quality of Life (QoL). Carnevale et al. [16] summarized the results as follows:

- All of the groups were comparable with regard to all pre-treatment parameters with the exception of urinary bladder contractility, and peak urine flow (Q-max), both of which had been significantly higher amongst PErFecTED PAE in comparison with TURP patients.
• All of the groups did experience significant improvement with regard to IPSS, QoL, prostate volume, and Q max.
• TURP and PErFecTED PAE both did result in significantly lower IPSS, QoL, in comparison with 0PAE, however, they were not significantly different from one another.
• TURP did result in significantly higher Q-max, and significantly smaller volume of the prostate in comparison with either original or PErFecTED PAE; nevertheless, TURP did require spinal anaesthesia and hospitalization.
• Two of the patients who were in the oPAE group and who had hypo-contractile urinary bladders did experience recurrence of symptoms and they were subsequently treated by means of TURP.
• With regard to the TURP group of patients, urinary incontinence did occur in 4 out of 15 patients that amounted to 26.7%, rupture of the prostatic capsule in 1 out of 15 patients that amounted to 6.7% of the patients, retrograde ejaculation in all of the 15 patients that amounted to 100%, and one of the patients was re-admitted for temporary irrigation of the urinary bladder due to haematuria.

Carnevale et al. [16] made the following conclusions:

• TURP and PAE are both safe procedures as well as effective treatment options.
• TURP and PErFecTED PAE do yield similar improvement of symptoms; however, TURP tends to be associated with both better urodynamics results as well as more adverse events.

Bagla et al. [31] undertook a study to ascertain the role of prostate volume as a predictor of outcome pursuant to prostatic artery embolization (PAE). Bagla et al. [31] reported that from January 2012 to September 2014, 78 consecutive patients who had undergone PAE were evaluated at baseline, and at 1-month, 3-months, and 6-months pursuant to PAE. They did undertake an analysis which compared the prostate gland volume groups which included group 1, prostate volume less than 50 cubic centimetres; group 2 prostate volume between 50 cubic centimetres and 80 cubic centimetres; group 3 prostate volume greater than 80 cubic centimetres; at baseline, and at follow-up in order to assess for differences related to the outcomes of the American Urological Association (AUA) symptom index, quality of life (QoL)-related symptoms, as well as the International Index of Erectile Function (IIEF). Bagla et al. [31] summarized the results as follows:

• With regard to group 1 that had consisted of 16 patients, the mean baseline prostate volume was 37.5 cubic centimetres, and with group 2, the mean baseline prostate volume of the 26 patients was 65.7 cubic centimetres, and for group 3 the mean prostate volume of 36 patients was 139.4 cubic centimetres.
• There had not been any significant differences with regard to baseline age, AUA symptom index, QoL, or IIEF amongst the three groups.
• Bilateral embolization was successfully carried out with regard to 75 out of 78 patients which had amounted to 96% of the patients. Two patients had undergone unilateral embolization, and the treatment did fail with regard to 1 patient as a result of bilateral atherosclerotic occlusion.
• A significant reduction with regard to the AUA symptom index had been achieved within the groups from baseline to 1 month-follow-up, 3 months-follow-up, and 3-months follow-up with regard to 77 patients that included: with regard to group 1, from 27.2 to 14.0, 12.9, and 15.9 respectively at P = 0.002; with regard to group 2, from 25.6 to 17.1, 16.3, and 13.5 respectively at P < 0.0001; and with regard to group 3, from 26.5 to 15.2, 12.5, and 13.6 respectively at P < 0.0001.
• There had not been any significant improvement with regard to QoL.
• Comparative analysis did not show any statistically significant differences with regard to AUA symptom index, QoL, or IIEF, between the three groups of patients.
• Two minor complications did occur which had included groin haematoma, and an episode of urinary tract infection.

Bagla et al. [31] concluded that PAE does offer benefits that are similar to patients who have differing prostate gland sizes and PAE could offer a reasonable alternative form of treatment for candidates that have a poor risk for the undertaking of urological surgery.

De Assis et al. [32] undertook a prospective, one centre, single arm study on 35 patients who whose prostate volumes had ranged from 90 grams to 252 grams. The ages of the patients had ranged between 53 years and 77 years and their mean age was 64.8 years. Magnetic resonance imaging scan, uroflometry, and the International Prostate Symptom Score, were utilized to assess the clinical and functional outcomes. de Assis et al. [32] summarized the results as follows:
Anthony Kodzo-Grey Venyo, **Prostatic Artery Embolization (PAE) As Treatment for Lower Urinary Tract Obstruction Due To Benign Prostatic Hyperplasia: An Update of the Literature**

- The mean size of the prostate gland did decrease from 135.1 grams before the procedure to 91.9 grams at the 3-month patient follow-up which was significant at \( P < 0.0001 \).
- The mean IPSS and Quality of Life Index did improve from 18.3 to 2.7 and 4.8 to 0.9 at \( P < 0.001 \) for both parameters respectively.
- A significant negative correlation had been found between the serum prostate-specific antigen level at 24 hours pursuant to the PAE and IPSS at 3 months pursuant to the PAE at \( P = 0.0057 \).

De Assis et al. [32] made the following conclusions:
- PAE represents a safe and effective treatment option for lower urinary tract symptoms secondary to benign prostate hyperplasia with regard to patients whose prostate volume/weight is greater than 90 grams.
- Excessively raised serum PSA level within 24 hours pursuant to PAE tends to be associated with lower symptom burden in short-term follow-up.

Pisco et al. [33] undertook a retrospective study of patients who between March 2009 and September 2014 who had undergone PAE for benign prostatic hyperplasia (BPH), prostate volume (PV) greater than 100 cubic centimetres, and moderate to severe lower urinary tract symptoms that had been refractory to medical therapy for six months or who did have acute urinary retention. With regard to the study, they defined successful procedure as (a) improved symptoms that included International Prostate Symptom Score equal to or less than 15, and decrease of equal to or greater than 25% from the baseline score, (b) improved quality of life which was measured as a score of equal to or less than 3 points or a decrease of equal to or greater than 1 point from the baseline, (c) and no need for any further treatment. Pisco et al. [33] summarized the results as follows:

- Prostate artery embolization (PAE) was undertaken on 152 patients whose ages had ranged between 48 years and 87 years with a mean age of 67.4 years and a standard deviation of plus / minus 7.5 and a mean prostate volume (PV) of 134.2 cubic centimetres plus or minus 41.8 cubic centimetres and a range of between 101 cubic centimetres and 383 cubic centimetres.
- Prostate artery embolization (PAE) was successful technically with regard to 149 patients that amounted to 98.0%.
- Symptomatic control had been attained for a median of 18 months plus / minus 15.5 months and a range of between 3 months and 66 months.
- Thirty three clinical failures were reported which amounted to 23.6%: 23 of the clinical failures did occur in the short term of equal to or less than 6 months, and 10 clinical failures did occur within the medium term of 6 months to 24 months; no long-term failures were reported for more than 36 months.
- The cumulative clinical success rates were noted as follows: 90%, 87.9%, 83.5%, 81.1%, and 77.8% at 1 month, 3 months, 6 months, 12 months, and 18 months, and 72.4% after that up to 66 months (five and half years).

Pisco et al. [33] concluded that PAE does provide a sustained short-term, medium-term, as well as long-term control for lower urinary tract symptoms (LUTS) in patients who have benign prostatic hyperplasia (BPH) and prostate volume (PV) greater than 100 cubic centimetres.

Carnevale et al. [34] reported the preliminary results of two patients who had been treated for acute retention of urine due to benign prostate hyperplasia by means of prostate artery embolization (PAE) successfully. The patients had been investigated by utilization of the International Prostate Symptom Score (IPSS), digital rectal examination, urodynamic testing, prostate biopsy, trans-rectal ultrasound scan (US), and magnetic resonance imaging (MRI). Uroflowmetry and post-void residual urine volume estimation were undertaken at 30 days, 90 days, and 180 days pursuant to the PAE. The PAE procedure was undertaken under local anaesthesia and the embolization of the prostatic arteries was undertaken with utilization of a microcatheter and 300- to 500- micrometre microspheres using complete stasis as the end point. One of the patients underwent bilateral PAE and one patient underwent unilateral PAE. The patients voided spontaneously pursuant to removal of the urethral catheter, 15 days, and 10 days after the PAE procedure respectively. At the 6-month follow-up, ultrasound scan, magnetic resonance imaging scan showed prostate volume reduction of 39.7% and 47.8%, respectively following the bilateral PAE and 25.5% and 27.8% respectively following the unilateral PAE. The early results at the 6-month follow-up did show a promising potential alternative with regard to the treatment of benign prostate hyperplasia (BPH).

Ray et al. [35] assessed the efficacy and safety of prostate artery embolization (PAE) as treatment for lower urinary tract symptoms (LUTS) ensuing benign prostatic hyperplasia (BPH) and to undertake an
indirect comparison of prostate artery embolization (PAE) with trans-urethral resection of prostate (TURP) as a joint initiative of the British Society of Interventional Radiologists, the British Association of Urological Surgeons (BAUS), and the National Institute for Health Care Excellence. Ray et al. [35] did conduct the United Kingdom (UK) register of Prostate Embolization (UK-ROPE) study, which had enrolled 305 patients across 17 United Kingdom (UK) Urological / Interventional Radiology centres, of whom 216 patients had undergone PAE, and 89 patients of whom did undergo trans-urethral resection of prostate gland (TURP). The primary outcomes of the study were improvement in the International Prostate Symptom Score (IPSS) of the PAE group at 12 months pursuant to the procedure, and complication rate pursuant to the PAE procedure. Ray et al. [35] additionally aimed to compare the improvement with regard to the International Prostate Symptom Score (IPSS) between the PAE group and the TURP group of patients by utilizing non-inferiority analysis on propensity-score-matched patient pairs. The clinical results as well as urological measurements were undertaken at clinical sites. The IPSS as well as other questionnaire-based results had been sent by mail by the patients directly to the trial unit management the study project. All of the data without any exception had been uploaded centrally into the UK-ROPE study data base. Ray et al. [35] summarized the results as follows:

- The results had shown that PAE was clinically effective and had produced a median of 10 point in the International Prostate Symptom Score (IPSS) improvement from the baseline IPSS at 12 months following the procedure.
- PAE had not appeared to be as effective as TURP procedure, which had produced a median of 15-point improvement in the International Prostate Symptom Score (IPSS) at 12 months pursuant to the procedure.
- The aforementioned findings had been further supported by the propensity score analysis, in which they did form 65 closely matched pairs of patients who had undergone PAE and patients who had undergone TURP.
- With regard to improvement in IPSS and Quality of Life (QoL) score, there had not been any evidence of PAE being non-inferior to TURP.
- The patients that were within the PAE group, did have a statistically significant improvement with regard to maximum urinary flow rate (Q-max), and reduction of prostate volume at 12 months pursuant to the PAE procedure.
- PAE did have a re-operation rate of 5% before 12 months post-procedure, and a re-operation rate of 15% after 12 months that amounted to a total re-operation rate of 20% post PAE.
- Out of 216 patients, one patient did develop sepsis, one patient did require blood transfusion, four patients did have local arterial dissection, and four patients did have haematoma of the groin. Two patients did have non-target embolization which had presented as self-limiting penile ulcers.
- The pain levels of the patients and return to normal activities of the patients were very encouraging for PAE.
- Seventy-one percent (71%) of the PAE patients had undergone their PAE procedures as either an outpatient procedure or as a day case procedure. In comparison, eighty percent (80%) of TURP patients did require at least one night of hospital stay, and the majority of the patients did require 2 nights of hospital stay.

Ray et al. [35] made the ensuing conclusions:

- Their results to illustrate that PAE does provide a clinically and statistically significant improvement with regard to symptoms and Quality of Life (QoL), even though some of these improvements had been better with regard to the TURP group of patients.
- The safety profile of PAE and the quicker return activities pursuant to PAE would be visualised or understood to highly beneficial by patients who do consider PAE procedure as an alternative option of treatment of BPH / lower urinary tract symptoms (LUTS), with the concomitant advantages of reduction in the length of hospital stay and the need to be admitted in the hospital after PAE.
- The procedure of PAE does represent an advanced embolization technique which does require a high level of expertise, and PAE should undertaken by an experienced interventional radiologist who has been adequately trained and proctored appropriately.
- The would encourage utilization of cone-beam computed tomography scan in order to improve upon operator confidence as well as in order to minimise non-target embolization.
- The place of PAE in the care pathway of LUTS/BPH is between that of drugs (medications) and surgery, and this would allow the clinician to tailor the treatment of the patient to the individual patient’s symptoms, requirements as well as anatomical variation.
It would be argued that PAE is a safe and effective treatment option for LUTS/BPH in that most of the procedures can be undertaken under local anaesthesia as either outpatient procedures or day case procedures which does not require utilization of spinal anaesthesia or general anaesthesia and the procedure could be undertaken for a number of patients who have some cardiac and respiratory tract problems who may have a high risk anaesthetic for undergoing the procedure under general anaesthesia. 

Bilhim et al. [36] undertook a randomized prospective study on 80 patients whose ages had ranged between 48 years and 81 years whose mean age was 63.9 years who had symptomatic BPH and who had undergone prostatic artery embolization (PAE) between May 2011 and December 2011. Forty of the reported patients who had been assigned to group A, did undergo PAE with utilization of 100 micrograms polyvinyl alcohol (PVA) particle size and 40 patients did undergo PAE with utilization of 200 micrograms PVA particle size who were assigned to group B. They utilized visual analogue scales to visualise to measure pain, and the rates of adverse events were recorded. Bilhim et al. [36] did evaluate the outcomes of the PAE procedures based upon the International Prostate Symptom Score (IPSS) and Quality of Life (QoL) questionnaires, prostate volume (PV), serum prostate-specific antigen (PSA) levels, and peak flow (Q-max) measurements at baseline and at 6 months pursuant to the PAE procedure of each patient. Bilhim et al. [36] summarized the results as follows:

- They did not notice any difference between the two groups A and B with regard to the baseline data, details of the procedures, or adverse events.
- The mean pain scores were as the ensuing:
  - During embolization, the mean pain score was 3.2 plus / minus 2.97 for group A patients in comparison with a mean pain score of 2.93 plus / minus 3.28 for group B patients at P = 0.20. and after the PAE procedure the mean pain score was 0.10 plus / minus 0.50 for group A patients and 0 for group B patients at P = 0.20. The week after the PAE, the mean pain score was 0.85 plus / minus 1.65 for patients in group A in comparison with a mean pain score of 0.87 plus / minus 1.35 for patients in group B.
  - The patients that were assigned to group B did have greater decreases in IPSS with a mean IPSS of 3.64 points at P = 0.052 and Quality of Life (QoL) of 0.57 points at P = 0.07. The patients that had been assigned to group A did have a greater decrease in prostate volume (PV) with a mean PV decreases of 8.75 cubic centimetres at P = 0.13 and serum PSA level of 2.09 ng / mL at P < 0.001.

Bilhim et al. [36] made the following conclusions:

- They did not notice any significant differences in the pain scores as well as adverse events between the two groups A and B.
- Nevertheless, serum PSA level and prostate volume (PV) did show greater reductions pursuant to PAE with utilization of 100 micrograms polyvinyl alcohol (PVA) particles and the clinical outcome was better with utilization of 200 micrograms particles of polyvinyl alcohol.

Uflacker et al. [37] undertook a meta-analysis of available data on prostate artery embolization (PAE) on articles that had been published between November 2009 and December 2015. They included peer-reviewed studies that had greater than 5 patients and standard deviations and / or individual-level data on one or more of the ensuing outcomes: prostate volume (PV), peak flow rate (Q-max), post-void residual urine volume (PVR), International Prostate Symptom Score (IPSS), Quality of Life (QoL) score, International Index of Erectile Function (IIEF) score, and serum prostate-specific antigen (PSA) level. Uflacker et al. [37] undertook a random-effects meta-analysis on the aforementioned outcomes at 1-month, 3-months, 6-months, and 12-months pursuant to the PAE and compared them with the baseline values, with a P < 0.05 decision rule as the null hypothesis rejection criterion. Uflacker et al. [37] summated the results as follows:

- They had included 19 out of 268 studies in the data collection and of these 6 studies were included in the meta-analysis.
- At 12 months, the prostate volume (PV) had decreased by 31.31 cubic centimetres at P < 0.001; the serum PSA had remained unchanged at P = 0.248; the post-void residual urine volume (PVR) had decreased by 85.54 mL at P < 0.001; the peak flow rate (Q-max) had increased by 5.39 millilitres per second at P < 0.001; the International Prostate Symptom Score (IPSS) had improved by 20.39 points at P < 0.001; the Quality of Life (QoL) score had improved by -2.49 points at P < 0.001; and the International Index of Erectile Function (IIEF) had remained unchanged at P = 1.0.
- A total of 218 adverse events (AEs) amongst 662 patients that amounted to 32.93% of the patients with 216 of them being the Society of Interventional Radiology Class A/B which did amount to 99% of the adverse events.
• The commonest complications had included: rectalgia / dysuria which occurred in 60 patients which amounted to 9.0% of the 662 patients, and acute retention of urine did occur in 52 patients which amounted to 7.8% of the 662 patients. No Class D/E complications had been reported.

Uflacker et al. [37] made the following conclusions:
• Prostate artery embolization (PAE) did provide improvement in Q-max, PVR, IPSS, and QoL end points at the 12-month follow-up and it was associated with a low incidence of serious adverse events (AEs) of 0.3%, even though minor adverse events (AEs) tended to be common at 32.93%.
• There was no adverse effect upon erectile function.

Russo et al. [38] did undertake a 1:1 matched-pair analysis of International Prostate Symptom score (IPSS), peak flow rate (PF/Q-max), post-void residual urine volume (PVR), as well as prostate volume (PV) of 287 consecutive patients who had undergone treatment for benign prostatic obstruction that included 80 patients who underwent open surgery, and 80 patients who had undergone prostate artery embolization. The declared inclusion criteria of the patients had included the ensuing: lower urinary tract symptoms, or benign prostatic obstruction, IPSS score of equal to or greater than 12, serum prostate-specific antigen (PSA) value of less than 4 ng / mL, or serum PSA value of between 4.0 ng / mL and 10.0 ng / mL but negative prostate biopsy excluding malignancy, total prostate volume greater than 80 cubic centimetres, and peak flow (Q-max) less than 15 millilitres per second. The post-procedure follow-up assessments were undertaken at 1 month, 6 months and 12 months post-procedure in the follow-up clinic. The primary end points of the study included: comparison regarding the IPSS, International Index of Erectile Function-5 (IIEF-5), peak flow (PF/Q-max), post-void residual urine volume (PVR), as well as IPSS-Quality of Life (IPSS-QoL) pursuant to 1 year of follow-up. Russo et al. [38] summarized the results as follows:
• With regard to the primary end-points, the open prostatectomy group of patients (OP Group) did have lower IPSS of 4.31 versus 10.40 at P < 0.05, one-year post void residual urine volume (PVR) of 6.15 versus 18.38 millilitres at P < 0.05, one-year serum PSA (PSA) of 1.33 versus 2.12 at P < 0.05, IPSS-QoL of 0.73 points versus 2.78 at P < 0.05, International Index of Erectile Function-5 (IIEF-5) at 10.88 versus 15.13 at P < 0.05, as well as greater peak flow rate (PF/Q-max) of 23.82 millilitres per second in comparison with 16.89 millilitres per second at P < 0.01.
• The matched-pair comparison did show higher value of post-operative haemoglobin level in milligrams per decilitre and shorter period of hospitalization in days as well as catheterization in days with regard to prostatic artery embolization (PAE) group of patients.
• Multivariate logistic regression analysis did reveal that prostatic artery embolization (PAE) was had been associated with persistent symptoms with IPSS of equal to or greater than 8 with odds ratio of 2.67 and 95% confidence interval (CI) of between 0.96 and 7.4 at P < 0.01 and with persistent peak flow-rate (Q-max) of equal to or less than 15 millilitres per second with odds ratio of 4.95 and 95% confidence interval (CI) of 1.73 to 14.15 at a P value of < 0.05 after one year.

Russo et al. [38] concluded that prostate artery embolization (PAE) could be considered to be a feasible minimally invasive option of treatment; nevertheless, PAE did fail to illustrate superiority to open surgery in view of the increased risk of persistence of symptoms as well as lower peak flow (PF/Q-max) after one year.

Shim et al. [12] undertook a systemic review with meta-analysis and meta-regression studies of the efficacy and safety of prostate artery embolization and based upon their findings they concluded that there is growing evidence to suggest the efficacy of prostatic arterial embolization (PAE) for benign prostatic hyperplasia but their review had indicated that prostatic artery embolization (PAE) should still be regarded as an experimental treatment modality option.

Antunes et al. [39] undertook a prospective study on 11 patients who had retention of urine as a result of BPH that had been treated by means of prostate artery embolization (PAE). The patients did undergo physical examination, measurement of their serum prostate-specific antigen (PSA), trans-rectal ultrasound scan, as well as magnetic resonance imaging (MRI). They utilized International Prostate Symptom Score (IPSS), Quality of Life (QoL), and urodynamic assessment to evaluate the outcome before the procedure and after one year. Antunes et al. [39] summarized the results as follows:
• Clinical success had been achieved in 10 out of the 11 patients which did amount to 91% of the patients with a follow-up that ranged between 12 months and 41 months and a mean follow-up of 22.3 months.
At the first year follow-up assessment, the mean IPSS was 2.8 points at P = 0.04; the mean Quality of Life (QoL) was 0.4 points at P = 0.001; the mean serum prostate-specific antigen (PSA) had dropped from 10.1 to 4.3 ng / mL at P = 0.003; the maximum urine flow rate (Q-max) had increased from 4.2 millilitres per second to 10.8 millilitres per second at P = 0.009; the detrusor pressure (Pdet) had dropped from 85.7 cm H2O to 51.5 cm H2O at P = 0.007.

Prior to the prostate artery embolization (PAE), Bladder Outlet Obstruction Index (BOOI) did reveal values greater than 40 cm of H2O in all the patients that had amounted to 100% of the patients.

Pursuant to the PAE 30% of the patients were demonstrated upon urodynamic testing to be obstructed with detrusor pressure greater than 40 cm of H2O, 40% of the patients upon urodynamics studies finding that was adjudged to be undetermined in that the detrusor pressure was between 20 cm H2O and 40 cm H2O, and 30% of the patients upon urodynamics studies were adjudged to be unobstructed in that their detrusor pressures were less than 20 cm H2O.

The patients who had bladder outlet obstruction index (BOOI) less than 20 did have higher serum prostate-specific acid (PSA) values at 1-day pursuant to the PAE procedure. Antunes et al. [39] made the ensuing conclusions:

- The clinical and urodynamics parameters had significantly improved pursuant to PAE in patients who had acute retention of urine as a result of benign prostatic hyperplasia (BPH).

- The total serum prostate-specific antigen (PSA) values on day 1 pursuant to PAE were higher in the patients who had obstructed urodynamic values in pressure flow studies.

Carnevale et al. [40] reported 105 consecutive patients who were older than 45 years, whose prostate gland sizes were greater than 30 cubic centimetres, who had International Prostate Symptom Score of equal to or greater than 8 points, whose Quality of Life (QoL) index score was equal to or greater than 3, who were adjudged to be in refractory status or had intolerance of medical management of their lower urinary tract symptoms, and who had been prospectively enrolled between June 2008 and August 2013. The patients had undergone original prostate artery embolization (oPAE) or proximal embolization first then embolize distal artery (PERFected (PErFecTED)) PAE and they had been followed-up for at least 12 months.

Carnevale et al. [40] did define technical success as bilateral embolization and clinical success of non-recurrence was defined by them as successful removal of the Foley catheter in patients who had retention of urine, IPSS of less than 8, and Quality of Life (QoL) score of less than 3 at 12 months follow-up. Carnevale et al. [40] utilized non-parametric statistics to compare the study groups due to the size of the study population as well as the distributions of the clinical data. Carnevale et al. [40] summated the results of the study as follows:

- Ninety seven of the 105 patients did have 12-months follow-up data and had been categorized as oPAE without recurrence which had included 46 patients, oPAE with recurrence which had included 13 patients, PErFecTED without recurrence which had included 36 patients and PErFecTED with recurrence which had included 2 patients.

- Recurrence had been significantly commoner in oPAE patients with utilization of X2 yielding a P value of 0.026.

- Unilateral embolization tended to be significantly associated with recurrence among patients who had undergone oPAE with utilization of X2 yielding a P value of 0.032.

Carnevale et al. [40] concluded that both oPAE and PErFecTED PAE are safe and effective modalities of treatment for lower urinary tract symptoms (LUTS); nevertheless, PErFecTED PAE tends to be associated with lower rate of recurrence of symptoms.

Amouyal et al. [41] reported 32 consecutive patients whose ages had ranged between 52 years and 84 years with a mean age of 65 years between December 2013 and January 2015 and who had been referred for prostate artery embolization pursuant to failure of medical therapy for lower urinary tract symptoms or refusal to undergo surgery or contraindication for surgery. The patients did undergo treatment with utilization of the PErFecTED technique, when feasible, with 300 microns to 500 microns calibrated microspheres with two nights hospitalization or as an outpatient procedure. The patients underwent follow-up assessments at 3 months, 6 months, and 12 months. Amouyal et al. [41] summarized the results as follows:

- They did have 100% immediate technical success of embolization, with 68% of feasibility of the PErFecTED technique with no immediate complications.

- At a mean follow-up of 7.7 months they had observed a 78% rate of clinical success; the mean IPSS had dropped from 15.3 to 4.2 with a P value of 0.03; the mean Quality of Life (QoL) had dropped from 5.4 to 2 with a P value of 0.03; the peak flow rate (Q-max) had increased from 9.2 millilitres per second to

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19.2 millilitres per second with a P value of 0.25; the mean prostate volume had decreased from 91 cubic millilitres to 62 cubic millilitres with a P value of 0.009; there was no retrograde ejaculation and no complication had developed.

Amouval et al. [41] made the following conclusions:
- Utilization of the PErFecTED technique is a safe and efficient technique to treat bothersome lower urinary tract symptoms (LUTS) associated with BPH.
- It is worth noting that PErFecTED technique cannot be undertaken in some cases because of anatomical reasons.

Wang et al. [42] undertook a literature review of 12 studies related to embolization prostatic artery due to lower urinary tract symptoms for benign prostatic hypertrophy from 1980 to 2016. Wang et al. [42] summarized the results as follows:
- They had included 12 studies that had involved 840 participants.
- In comparison with the baseline findings, the International Index of Erectile Function-5 (IIEF-5) scores, International Prostate Symptom Score (IPSS) results, Quality of Life (QOL) scores, peak flow rate (Q-max), as well as post-void residual urine volume (PVR) rates all did have improvements that were significant during the 24-months follow-up of the patients and all of the parameters did have a P value of < 0.00001. Both prostate volume (PV) and serum prostate-specific acid (PSA) had significantly decreased during the 12-month post PAE follow-up with P values at < 0.00001 and 0.005 respectively with the exception of post-operative 24 months P values of P = 0.47 and P = 0.32 respectively. The IIEF-5 short-form scores did increase significantly at post-PAE 6-months with a P value of P = 0.002, and at 12 months the P value was P < 0.0001 but the post PAE P values after 1 month and 24 months were respectively P = 0.23, and P = 0.21 respectively. With regard to large volume prostates with the prostate volume being equal to or greater than 80 mL, the results were similar to the aforementioned results. There had not been any life threatening complications.

Wang et al. [42] made the following conclusions:
- Prostate artery embolization (PAE) is an effective, safe, as well as tolerable treatment option for lower urinary tract symptoms (LUTS) that are related to benign prostatic hyperplasia (BPH) including large volume BPH with prostate volumes that are equal to or greater than 80 mL with a short term follow-up.
- Studies related to PAE with large numbers of patients as well as longer follow-up times would be needed in order to validate their results.

Li et al. [43] reported that between July 2012 and June 2014, they had undertaken prostate artery embolization on 24 patients whose ages had ranged between 65 years and 85 years with a mean age of 74.5 years that had severe lower urinary tract symptoms (LUTS) as a result of benign prostatic hyperplasia (BPH) and which was refractory to medical therapy. Embolization was undertaken with utilization of a combination of 50 micrometer and 100 micrometre in particle sizes. Clinical follow-up assessments were undertaken with utilization of the International Prostate Symptom Score (IPSS), Quality of Life (QoL) score, peak urine flow rate (Q-max), post-void residual urine volume (PVR), International Index of Erectile Function (IIEF), serum prostate-specific acid (PSA), and prostate volume (PV) which had been measured magnetic resonance imaging (MRI) at 1 month, 3 months, 6 months, and every 6 months thereafter. Li et al. [43] defined technical success as when PAE had been completed in at least one side of the pelvis. Li et al. [43] defined clinical success as improvement with regard to both symptoms and quality of life. They utilized student’s t tests for paired samples in their analysis. Li et al. [43] summarized the results as follows:
- PAE was technically successful with regard to 22 patients which had amounted to 92% of the patients.
- Bilateral PAE was undertaken with regard to 19 patients which had amounted to 86% of the patients (see figure 1 for example), and unilateral PAE was undertaken with regard to 3 patients which amounted to 14% of the patients (see figure 2 for an example).
- Follow-up data had been available for 22 patients who had been followed-up for a mean of 14 months.
- The documented improvement at 1 month, 3 months, 6 months, and 12 months was 91%, 91%, 88%, and 83% respectively.
- At the 6-month follow-up assessment, the mean IPSS, QoL score, PVR, and Q-max had been recorded as 27 to 8 with a P value of P = 0.001, from 4.5 to 2.0 at P value of P = 0.002, from 140.0 millilitres to 55.0 millilitres with a P value of P = 0.002, and from 6.0 millilitres per second to 13.0 millilitres per second with a P value of P = 0.001 respectively.
- The mean prostate volume did decrease from 110 cubic centimetres to 67.0 cubic centimetres with a mean prostate volume reduction of 39.1% and with a P value of P = 0.001.
The serum prostate-specific antigen (PSA) and IIEF improvements pursuant to PAE had not differed from the pre-PAE results significantly.

No adverse events had been documented.

Li et al. [43] made the following conclusion:

The combination of 50 micrometre and 100 micrometre particles for prostate artery embolization (PAE) is a safe and effective treatment technology for patients who have severe lower urinary tract symptoms (LUTS) due to large benign prostatic hyperplasia (BPH), which does further improves the clinical outcomes of PAE.

Figures 1:(a - i). Images from an 82-year-old man with significant lower urinary tract symptoms due to large benign prostatic hyperplasia (BPH) (100 cm³) underwent bilateral prostatic artery embolization (PAE). (a) Cone-beam computed tomography (CT) image with coronal view after super-selective catheterization of the right prostatic artery (>) contrast medium staining in the right prostate lobe (*). (b) Image obtained at the end of embolization shows complete embolization of the right prostatic artery (>) and the right prostatic lobe opacification (*). (c) Cone-beam CT image with coronal view after super-selective catheterization of the left prostatic artery (>) demonstrates contrast medium staining in the left prostate lobe (*). (d) Image obtained at the end of embolization shows complete embolization of the left prostatic artery (>) and the left prostatic lobe opacification (*). (e) Axial contrast-enhanced T1-weighted magnetic resonance image (MRI) obtained before PAE shows a large BPH (straight arrows). (f) Coronal contrast-enhanced T1-weighted MRI obtained at 1-month after PAE shows significantly infarcted areas (85%) on both sides of the prostate (straight arrows). (g) Axial contrast-enhanced T1-weighted MRI obtained at 3 months after PAE shows significantly infarcted areas on both sides of the prostate (straight arrows), with volume reduction of 32%. (h) Axial contrast-enhanced T1-weighted MRI obtained at 6-months after PAE shows significantly infarcted areas on both sides of the prostate (straight arrows), with volume reduction of 45%. (i) Axial contrast-enhanced T1-weighted MRI obtained at 12 months after PAE shows the prostate volume reduction of 46%; this patient experienced marked clinical improvement during 18-month follow-up, with International Prostate Symptom Score improvement of 80%. Reproduced from: [43] Li Q, Duan F, Wang M Q, Zhang G D, Yuan K. Prostatic Arterial Embolization with Small Sized Particles for the Treatment of Lower Urinary Tract Symptoms Due to Large Benign Prostatic Hyperplasia: Preliminary Results. Chinese Medical Journal. (Engl). 2015 Aug 5; 128(15): 2072 – 2077. DOI: 10.4103/0366-6999.161370


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De Assis et al. [44] undertook a retrospective study of 93 consecutive patients who had undergone prostatic artery embolization from 2010 to 2014. The baseline and the 6-month follow-up assessments of the patients included MRI of prostate with whole prostate (WP) and central gland (CG) volume measurements as well as measurement and calculation of prostate zonal volumetry index (ZVi) which was defined as CG/WP volumes relation, the International Prostate Symptom Score (IPSS), and the Quality of Life (QoL) index. The baseline values of WP, CG, as well as ZVi were compared statistically with the IPSS and QoL at the 6-month follow-up. De Assis et al. [44] summarized the results as follows:

- A total of 93 consecutive patients had been included in the study whose ages had ranged between 51 years and 86 years with a mean age of 63.4 years.
- They had defined clinical failure as IPSS > 7, or QoL >2 which was found in 4 of the patients that amounted to 4.3% of the patients.
- The mean reductions in the volume of the prostates pursuant to the PAEs were 30.6%, and 31.2% for WP and CG respectively with a P value of P < 0.0001.
- The clinical parameters did have a mean decrease from 21 points to 3.3 points for IPSS, and from 4.7 to 1.2 points for QoL score with a p value of P < 0.0001.
- The baseline WP, CG, as well as ZVi did correlate to the degree of clinical improvement with a p value of P < 0.05 for all of the three parameters.
- The baseline ZVi cut-off calculated for better clinical outcomes was > 0.45 and this had 85% sensitivity and 75% sensitivity.

De Assis et al. [44] made the ensuing conclusions:
- Baseline CP and WP volumes as well as ZVi did present strong correlation with the clinical outcomes of the patients who had undergone PAE, and the assessments of these aforementioned values should be considered during the pre-treatment assessments whenever it is possible.
It is important for both the patients as well as the medical team to be aware of the possibility of less favourable outcomes pursuant to PAE for lower urinary tract symptoms (LUTS) in individuals who have benign prostatic hyperplasia (BPH) if the ZVi value is < 0.45.

Carnevale et al. [45] stated that Prostate Artery Embolization has emerged as a new therapeutic option for patients who have symptomatic benign prostatic hyperplasia. Carnevale et al. [45] pointed out that the main challenges related to PAE include navigating arteries that have atherosclerosis and those arteries that have anatomical variations as well as the potential risk for the development of non-target embolization to pelvic structures as a result of presence of collateral shunts and reflux of microparticles. Carnevale et al. [45] stated that knowledge of the classical vascular anatomy to the prostate as well as the commonest variations in the vascular anatomy is essential for the safe embolization, good clinical practice, as well as optimal outcomes pursuant to the PAE procedures.

Wang et al. [46] reported a total of 117 patients whose prostates measured greater than 80 millilitres who had lower urinary tract symptoms due to benign prostatic hyperplasia and all of the 117 patients were documented to have been medical therapy failures for the treatment of their benign prostatic hyperplasia and they were not suitable candidates to undergo surgical operations for their benign prostatic hyperplasia. Prostatic artery embolization was undertaken with utilization of a combination of 50 micrometres and 100 micrometres particles with regard to size under local anaesthesia through a unilateral approach. The clinical follow-up assessments of the patients were undertaken with utilization of the International Prostate Symptom Score (IPSS), Quality of Life (QoL) score, peak urinary flow rate (Q-max), post-void residual urine volume (PVR), International Index of erectile function short form (IIEF-5), serum prostate-specific antigen (PSA), and prostatic volume (PV) which was measured by means of magnetic resonance imaging (MRI) scans at 1 month, 3 months, 6 months, and every 6 months thereafter. Wang et al. [46] summarized the results as follows:

- The prostatic artery origins within their study were different form the previously published results.
- PAE had been adjudged to be technically successful with regard to 109 out of the 117 patients which had amounted to 93.2% of the patients.
- Follow-up data had been available for 105 patients who had a mean follow-up of 24 months.
- The documented clinical improvements associated with the IPSS, QoL scores, Q-max, PVR, and PV at 1 month, 3 months, 6 months, 12 months, and 24 months were documented as 94.3%, 94.3%, 93.3%, 92.6%, and 91.7% respectively.
- The mean IPSS pre-PAE versus post-PAE were 26.0 versus 9.0 with a P value of P 0.01; the mean QoL was 5.0 versus 3.0; the mean Q-max was 8.5 versus 14.5 with a P value of P < 0.01; the mean PVR was 125.0 millilitres versus 40.0 millilitres with a P value of P < 0.01; the PV was 118.0 versus 69.0, with a mean reduction in PV of 41.5% and with a P value of P < 0.01 at 24 months pursuant to PAE were significantly different in comparison with the baseline results.
- The mean IIEF-5 had not been statistically different from the baseline IIEF-5.
- No major complications emanated.
- Wang et al. [46] made the ensuing conclusions:
- PAE is a safe as well as effective therapeutic method for patients who have LUTS due to large volume BPH.
- PAE could play an important role in men in whom medical treatment has failed and who are not suitable candidates for open prostatic surgery or trans-urethral resection of prostate (TURP), or men who have refused any surgical treatment.

Kuang et al. [47] undertook a review of some reported studies related to embolization of prostatic artery as treatment of lower urinary tract symptoms due to BPH. They reported that their search of the literature had yielded 193 articles, of which ten studies that represented 788 patients whose mean age was 66.97 years who were included in the study. The lower urinary tract symptoms of the patients had ranged from moderate symptoms to severe symptoms. At 6 months pursuant to the PAE procedure, the PV, PVR, Q-max, IPSS, and QoL had improved significantly with a P value of P < 0.05 but there was no significant change in the serum PSA. At 12 months and 24 months follow-up, the PV, serum PSA, PVR, Q-max, IPSS, and QoL had significantly improved with a P value of P < 0.05. The IIEF had not changed at 6 months and 12 months but the IIEF had been significantly reduced at their 24 months follow-up. Kuang et al. [47] concluded that their study PAE is effective with regard to the treatment of LUTS in the short and intermediate term.
Little et al. [48] investigated the clinical impact of prostatic artery embolization (PAE) upon patients who have adenomatous dominant benign prostatic hyperplasia (AdBPH) by including 12 patients from an ongoing prostatic artery embolization for the treatment of benign prostatic hyperplasia (STREAM) trial as having AdBPH which was defined as two or more adenomas within the central gland of equal to or greater than 1 cm diameter upon multi-parametric MRI (MP-MRI) scan. These 12 patients were age matched with patients from the STREAM cohort of patients who did not have AdBPH. The patients had repeat MP-MRI at their 3-months and 1-year follow-up. Little et al. [48] recorded at 6 weeks, 3 months and 1 year, pre-PAE, the International Prostate Symptom Score (IPSS), International Index of Erectile Function (IIEF), and Quality of Life (QoL) assessments from the IPSS and EQ-5D-5S questionnaires. Little et al. [48] summarized the results as follows:

- The ages of the ages had ranged between 61 years and 76 years with a mean age of 68 years.
- All of the patients did have their PAE treatments as day-case procedures.
- The technical success within the cohort was 23 out of 24 which amounted to 96% of the patients.
- There was a significant reduction in prostate volume pursuant to embolization which had ranged between 30% and 55% with a mean reduction in prostate volume of 34% with regard to the AdBPH group of patients in comparison with a prostate volume reduction which had ranged between 9% and 44% with a mean prostate volume reduction of 22% with regard to the non-AdBPH group of patients with a P value of \( P = 0.04 \).
- There was a significant reduction in the IPSS of the AdBPH group of patients pursuant to PAE in comparison with the control group of the non-AdBPH group of patients with an IPSS that had ranged between 3 and 15 and a mean IPSS of 8 in comparison with an IPSS that had ranged between 8 and 18 and a mean IPSS of 13 in the non-AdBPH group of patients with a P value of \( P = 0.001 \).
- The IPSS QoL scores did significantly improve in the AdBPH group with a P value of \( P = 0.007 \).
- There was no worsening in sexual function in either the AdBPH and in the non-AdBPH group.

Little et al. [48] concluded that AdBPH had been identified as being a predictor of clinical success pursuant to PAE.

Bagla et al. [13] undertook a cost analysis of prostate artery embolization (PAE) and trans-urethral resection of prostate gland (TURP) in the treatment of benign prostatic hyperplasia in a study that had included 86 men who had TURP whose mean age was 71.3 years and 70 men who underwent PAE whose mean age was 64.4 years with a P value of \( P < 0.0001 \). Bagla et al. [13] reported the following results:

- The intra-procedural supplies for PAE were significantly more expensive in comparison with for TURP in that the cost for PAE was $1472.77 in comparison with $1080.84 for TURP with a P value of \( P < 0.0001 \).
- When anaesthesia supplies and nursing as well staffing costs were included, the costs were noted to be significantly more expensive for TURP in comparison with PAE in that the cost for TURP was $2153.64 in comparison with $1667.10 at P value of \( P < 0.0001 \).
- The average length of stay in hospital for trans-urethral resection of prostate (TURP) group was 1.38 days in comparison with 0.125 days for the PAE group that was shorter.
- The total in-hospital costs for the trans-urethral resection of prostate (TURP) group was $5338.31 with standard deviation of $3521.17 which were significantly higher in comparison with the costs of $1678.14 with standard deviation of $442.0 with a P value of \( P < 0.0001 \).

Bagla et al. [13] concluded that in comparison with TURP, PAE tended to be associated with significantly lower direct in-hospital costs and shorter hospital stay.

Hwang et al. [49] reported the early results following prostate artery embolization (PAE) and they compared the outcomes between non-spherical polyvinyl alcohol (PVA) particles and microspheres to treat lower urinary tract symptoms (LUTS) related to benign prostatic hyperplasia (BPH). Hwang et al. [49] reported that PAE was undertaken in 9 patients whose mean age was 78.1 years who had symptomatic BPH. Embolization was undertaken with utilization of non-spherical PVA particles that measured between 250 micrometres and 355 micrometres in four patients and between 300 micrometres and 500 micrometres with regard to 5 patients. Hwang et al. [49] summarized the results as follows:

- PAE had been technically successful with regard to all of the 9 patients which amounted to 100% of the patients (see figures 3 and 4 which illustrate radiology imaging features of one of the patient’s procedures undertaken).
- During a mean follow-up of 10.1 months, improvements were noted with regard to various assessed parameters including: the mean International Prostate Symptom Score (IPSS), Quality of Life (QoL) score,
prostatic volume (total volume and transition zone), and peak urine flow rate (Q-max), which were 9.8 points, 2.3 points, 28.1 Millilitres, 17.8 millilitres, and 4.5 millilitres per second respectively.

- Clinical success had been obtained with regard to 7 out of the 9 patients which amounted to 78% of the patients.
- The patients that were within the micro-sphere group did show greater improvement with regard to IPSS, QoL, prostatic volume (PV), as well as in Q-max, in comparison with patients that were within the non-spherical PVA particle group. Nevertheless, significant difference had been noted only in the prostatic volume.

Hwang et al. [49] made the following conclusions:

- PAE represents a feasible, effective, and safe therapeutic option for BPH with LUTS.
- Utilization of micro-spheres did show greater prostatic volume reduction in comparison with non-spherical PVA particles.

Figure 3: Arteriographic images of a 76-year-old patient having lower urinary tract symptoms associated with benign prostatic hyperplasia who underwent bilateral prostatic embolization. Arteriograms obtained on both pelvic sides before (a, b, d, e) and after (c, and f) embolization under AP (b and e) and ipsilateral oblique views (a, c, d, and f) showing the bilateral prostatic arteries (arrows). The left prostatic artery originated from the inferior gluteal artery (arrowheads, a), and the right one originated from the internal pudendal artery (arrowheads, d). In the parenchymal phase of prostatic arteriography, prostate glands (asterisks, b and e) are opacified by bilateral prostatic arteries. After embolization using 300-500 um microspheres, the bilateral prostatic arteries were successfully embolized (c and f).

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Figure 4: Trans rectal ultrasound (US) images before embolization and at follow-up after prostatic artery embolization (PAE) (the same case as shown in Figure 3). Total volume (a and c) and transition zone volume (b and d) were obtained. US images obtained before PAE (a and b) and 24 months after PAE (c and d) showing marked reduction in prostatic volume.


Moreira et al. [50] reported a case of ischaemic rectitis in a 76-year-old man who had significant lower urinary tract symptoms as a result of benign prostatic hyperplasia which had been adjudged to be probably related to non-target embolization. He had magnetic resonance imaging (MRI) scan which showed an 85.5 grams prostate gland and he also had urodynamy study which showed lower urinary tract obstruction. He underwent bilateral PAE. During the first 3 days of his follow-up he was noted to have a small amount of blood mixed with his stool. He underwent colonoscopy which showed rectal ulcers on the 4th post PAE day, which had disappeared by the 16th post PAE day without any treatment.

Moreira et al. [50] stated that PAE is a safe, effective procedure that tends to be associated with a low complication rate, but interventionalists should be cognisant of the risk of rectal non-target embolization. Feng et al. [51] included 20 eligible studies in a meta-analysis to evaluate the clinical efficiency and safety of PAE in the treatment of moderate and severe LUTS related to BPH. They summarized their results as follows:

Synthetic data had shown that there had been statistically significant improvements with regard to:
- IPSS (MD = -13.25; 95% CI -14.81 -11.69; P < 0.00001),
- QoL score (MD = -2.34; 95% CI -2.69 - 2.00; P < 0.00001),
- Serum PSA level (MD = -1.33; 95% CI -1.86 - 0.80; P < 0.00001),
- PV (MD = -28.00 95% CI -35.94 - 20.07; P < 0.00001),
- Q-max (MD = 5.51; 95% CI 4.62 - 6.40; P < 0.00001), and
- PVR (MD = -67.8; 95% CI -81.35 - 53.60; P < 0.00001).

There was no difference with regard to the IIEF score. (MD = 0.93; 95% CI 0.43 - 1.42; P = 0.07.

The major complications that ensued PAE included pain within the perineum, the retro-pubic area, and or urethra in 9.4% of patients, and haematuria in 9.0% of patients.

Feng et al. [51] concluded that PAE should be regarded as a very promising alternative for lower urinary tract symptoms related to benign prostatic hyperplasia with regard to those patients who do not want to undergo surgical treatment or cannot tolerate surgical treatment due to its benefits upon the IPSS, QoL score, serum PSA level, PV, Q-max, and PVR without affecting the erectile function of the patient.

Rampoldi et al. [52] prospectively assessed the discontinuation of indwelling urinary bladder catheter (IBC) and relief of lower urinary tract symptoms (LUTS) related to benign prostatic hyperplasia (BPH) following prostatic artery embolization (PAE) in poor surgical candidates. Rampoldi et al. [52] summarized the results as follows:
Forty three patients had been enrolled in the study and of these, 33 patients had undergone bilateral PAE which amounted to 76.7% of patients and 8 patients that had amounted to 18.6% of the patients had undergone unilateral PAE, and two patients that amounted to 4.7% of patients could not undergo embolization in view of tortuosity and atherosclerosis of the pelvic vasculature.

With regard to the patients who had undergone embolization, the mean size of the prostate gland had decreased from 75.6 plus / minus 33.2 to 63.0 plus / minus 23.2 grams (sign rank P = 0.0001, mean reduction of 19.6 plus / minus 17.3%), intra-urinary bladder catheter removal (IBC) had been attained with regard to 33 patients which had amounted to 80.5% of the patients.

Clavien II complications had been reported in 9 patients which amounted to 21.9% of the patients and these included urinary tract infection in three patients that amounted to 7.3% of patients, recurrent acute retention of urine which had occurred in six patients which amounted to 14.6% of the patients.

Nine patients that amounted to 22.0% of the patients did experience post-embolization syndrome.

Rampoldi et al. [52] concluded that PAE is a safe and feasible option of treatment for lower urinary tract symptoms (LUTS) and indwelling urinary bladder catheterization (IBC) in highly co-morbid patients who do not have surgical treatment options.

It would be argued that since 22.0% of patients who underwent PAE developed post-embolization syndrome and there is no way any clinician can tell who will develop post-embolization syndrome and who will not develop post-embolization syndrome, all patients who undergo PAE should have a prophylactic hydrocortisone injection preceding the PAE and oral steroids for example prednisolone orally for a few days after undergoing PAE to avoid the development of post-embolization syndrome.

CONCLUSIONS

PAE is a safe and effective alternative option of treatment for individuals who have failed to respond well to medical treatment for lower urinary tract symptoms related to benign prostatic hyperplasia who are not fit to undergo surgery or who do not want to undergo surgical operation for BPH. PAE tends to be undertaken under local anaesthesia as outpatient procedure or day case procedure. The overall cost for undergoing PAE is less in comparison with TURP due the fact the patients do not need to be hospitalized. No significant major side effects tend to develop following PAE but urinary tract infection, rectal pain, longer periods of urethral catheterization as well as non-target embolization could occur. There tends to be short-term and medium-term improvements in IPSSS, QoL score, PVR, Q-max and reduction in prostate volume following PAE but the long-term outcome of the procedure is not well known.

The sexual function and ejaculation tends to be maintained following PAE. PAE should be undertaken in selected patients who have failed medical therapy for symptomatic BPH and do not want surgery or are not fit to undergo surgery. In order to establish the long term outcome of PAE as treatment for BPH, clinicians should be encouraged to report their experience related to PAE as treatment with long-term follow-up and they should also establish large multi-centre studies related to PAE for BPH with long-term follow-up; meanwhile PAE should remain an experimental alternative treatment for patients who cannot undergo surgery for BPH.

CONFLICT OF INTEREST – None

ACKNOWLEDGEMENTS

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