NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedure overview of prostate artery embolisation for benign prostatic hyperplasia

Benign prostatic hyperplasia (BPH) is a non-cancerous enlargement of the prostate. It can block or narrow the tube that urine passes through to leave the body, causing urination problems. In this procedure, using X-ray guidance, a thin tube called a catheter is inserted into an artery in the groin. It is guided into the blood vessels that supply the prostate. Small particles are then injected into these vessels. This reduces the prostate's blood supply, with the aim of shrinking it.

Contents

Introduction

The National Institute for Health and Care Excellence (NICE) prepared this interventional procedure overview to help members of the interventional procedures advisory committee (IPAC) make recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the

medical literature and specialist opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This overview was prepared in August 2017.

Procedure name

- Prostate artery embolisation for benign prostatic hyperplasia.

Specialist societies

- British Society of Interventional Radiology
- British Association of Urological Surgeons
- Royal College of Surgeons
- Royal College of Radiologists.

Description of the procedure

Indications and current treatment

Benign prostatic hyperplasia (BPH) is a common condition that affects older men. Stromal and epithelial cells increase in number, causing the prostate to increase in size. It often occurs in the periurethral region of the prostate, with large discrete nodules compressing the urethra. Symptoms include hesitancy during micturition, interrupted or decreased urine stream (volume and flow rate), nocturia, incomplete voiding and urinary retention.

Mild symptoms are usually managed conservatively. Drugs may also be used, such as alpha blockers and 5-alpha-reductase inhibitors. If other treatments have not worked, then surgical options include transurethral resection of the prostate (TURP), transurethral vaporisation of the prostate, holmium laser enucleation of the prostate or prostatectomy (see the NICE guideline on lower urinary tract symptoms in men). Insertion of prostatic urethral lift implants has been introduced more recently as an alternative treatment for lower urinary tract symptoms secondary to benign prostatic hyperplasia. Potential complications of surgical procedures include bleeding, infection, strictures, incontinence and sexual dysfunction.

What the procedure involves

Prostate artery embolisation for benign prostate hyperplasia is usually done using local anaesthesia. Under x-ray guidance, the prostate is approached through the

left or right femoral artery. Super-selective catheterisation of the small prostatic arteries is done using fine microcatheters through the internal iliac and vesical arteries. Embolisation involves the introduction of microparticles to completely block the prostatic vessels. Embolisation agents include polyvinyl alcohol (PVA) and other newer synthetic biocompatible materials. The aim of prostate artery embolisation is to reduce the prostate's blood supply, causing some of it to undergo necrosis and shrink. It is common for patients to experience pelvic pain during and after the procedure. This does not usually last more than 1 to 3 days. The potential benefits of prostate artery embolisation compared with surgery include fewer complications and avoiding a general anaesthetic.

Outcome measures

International Prostate Symptom Score

The International Prostate Symptom Score (IPSS) is a validated questionnaire often used to assess symptoms of BPH (it is also referred to as the American Urological Association BPH Symptom Score Index). It includes questions on incomplete bladder emptying, frequency, intermittency and urgency of urination, weak urine stream, straining to urinate and nocturia. Higher scores represent worse symptoms. In general, an IPSS symptom score of 0 to 7 indicates mild symptoms, 8 to 19 indicates moderate symptoms and 20 to 35 indicates severe symptoms. An additional question asks men how they feel about their BPH symptoms and the response yields a score for quality of life (ranging from 0 to 6, with 0 representing 'delighted' and 6 representing 'terrible').

International Index of Erectile Function

The International Index of Erectile Function (IIEF) is a 15-item questionnaire used to assess men's sexual function in 5 domains: erectile function, orgasmic function, sexual desire, intercourse satisfaction, and overall satisfaction. Each domain has its own score range and lower scores represent greater dysfunction:

- Erectile function score: range 0 to 30 (scores of 24 or less represent increasing dysfunction)
- Orgasmic function score: range 0 to 10 (scores of 8 or less represent increasing dysfunction)
- Sexual desire score: range 0 to 10 (scores of 8 or less represent increasing dysfunction)
- Intercourse satisfaction score: range 0 to 15 (scores of 12 or less represent increasing dysfunction)
- Overall satisfaction score: range 0 to 10 (scores of 8 or less represent increasing dysfunction).

Efficacy summary

International Prostate Symptom Score

In a systematic review of 16 studies (n=1,047), the standardised mean difference in the mean change from baseline in the International Prostate Symptom Score (IPSS) for prostate artery embolisation (PAE) compared to the control groups (either open prostatectomy or transurethral resection of the prostate) was 0.88 (95% confidence interval [CI] 0.10 to 1.66; 3 comparative studies)[1]. In the non-comparative studies included in the systematic review, the weighted mean difference in mean change from baseline in the IPSS was -12.77 (95% CI -15.04 to -10.50). In a case series of 630 patients, the mean improvement in IPSS was 12.1(±8.6) at 36-month follow-up (p<0.0001; n=328)[5].

Improvement of lower urinary tract symptoms

In the case series of 630 patients, 35% (218/630) of patients had immediate improvement of lower urinary tract symptoms; 95% (60/67) of patients with acute urinary retention had the bladder catheter removed and were able to spontaneously void between 2 days and 3 months after the procedure[5]. In the same study, clinical success was reported in 91% (95% CI 89% to 93%) of patients at 1-month follow-up (n=571) and 81% (95% CI 77% to 84%) of patients at 36-month follow-up (n=232).

Maximal urinary flow

In the systematic review of 16 studies (n=1,047), the standardised mean difference in the mean change from baseline in maximal urinary flow for PAE compared to the control groups was -1.44 (95% CI -2.30 to -0.58; 3 comparative studies)[1]. In the non-comparative studies, the weighted mean difference in mean change from baseline in maximal urinary flow was 5.29 (95% CI 4.35 to 6.23). In the case series of 630 patients, the mean improvement in maximal urinary flow was 3.2(±10.3) ml/min at 36-month follow-up (p<0.0001; n=328)[5].

International Index of Erectile Function

In the systematic review of 16 studies (n=1,047), the standardised mean difference in the mean change from baseline in International Index of Erectile Function (IIEF) for PAE compared to the control groups was 0.05 (95% CI -1.52 to 1.62; 3 comparative studies)[1]. In the non-comparative studies, the weighted mean difference in mean change from baseline in IIEF was 1.31 (95% CI 0.82 to 1.81). In the case series of 630 patients, the mean improvement in IIEF was 1.2(±5.7) at 36-month follow-up (p<0.0001; n=328)[5]. The IIEF score improved or stayed the same in 64% of patients.

Post-void residual urine volume

In the systematic review of 16 studies (n=1,047), the standardised mean difference in the mean change from baseline in post-void residual urine volume for PAE compared to the control groups was 0.14 (95% CI -0.18 to 0.46; 3 comparative studies)[1]. In the non-comparative studies, the weighted mean difference in mean change from baseline in post-void residual urine volume was -66.89 ml (95% CI -77.09 to -56.68). In the case series of 630 patients, the mean reduction in post-void residual urine volume was 37.4(±82.7) ml at 36-month follow-up (p<0.0001; n=328)[5].

Prostate-specific antigen

In the systematic review of 16 studies (n=1,047), the standardised mean difference in the mean change from baseline in prostate-specific antigen (PSA) level for PAE compared to the control groups was 0.46 (95% CI -0.02 to 0.95; 3 comparative studies)[1]. In the non-comparative studies, the weighted mean difference in mean change from baseline in PSA value was -0.78 ng/ml (95% CI -1.86 to 0.30). In the case series of 630 patients, the mean reduction in PSA value was 1.3(±5.9) ng/ml at 36-month follow-up (p<0.0001; n=328)[5].

Quality of life

In the systematic review of 16 studies (n=1,047), the standardised mean difference in the mean change from baseline in the quality of life score for PAE compared to the control groups was 0.25 (95% CI -0.28 to 0.77; 3 comparative studies)[1]. In the non-comparative studies, the weighted mean difference in mean change from baseline in the quality of life score was -2.34 (95% CI -2.72 to -1.97). In the case series of 630 patients, the mean improvement in quality of life score was 1.7(±1.3) at 36-month follow-up (p<0.0001; n=328)[5].

Prostate volume

In the systematic review of 16 studies (n=1,047), the standardised mean difference in the mean change from baseline in prostate volume for PAE compared to the control groups was 0.48 (95% CI 0.14 to 0.82; 3 comparative studies)[1]. In the non-comparative studies, the weighted mean difference in mean change from baseline in prostate volume was -29.79 (95% CI -36.99 to -22.58). In the case series of 630 patients, the mean reduction in prostate volume was 14.0(±27.3) cm^3 or 12.6%(±26.9) at 36-month follow-up (p<0.0001; n=328)[5].

Clinical Failure or Recurrence

In a randomised controlled trial (RCT) of 114 patients who had PAE or transurethral resection of the prostate (TURP), which was also included in the systematic review, clinical failure (defined as persisting severe symptoms after the procedure) was reported in 9% (5/57) and 4% (2/53) of patients respectively[2]. In an RCT of 45 patients, which was also included in the systematic review, 13%

(2/15) of patients in the original PAE group had recurrence of lower urinary tract symptoms compared with no patients in the 'PErFecTED' ['proximal embolisation first, then embolise distal'] PAE group and no patients in the TURP group[3]. In the case series of 630 patients there were 104 (18%) clinical failures: 85 (83%) up to 1 year after PAE, 14 at 1 to 3 years after PAE and 5 at long-term follow-up. Of the 85 short-term clinical failures, 50 (55%) were within 1 month, 7 occurred at 3 months, 13 were at 6 months, and 15 were at 12 months[5]. In a case series of 97 patients, recurrence was statistically significantly more common in the original PAE cohort compared with the PErFecTED cohort (22% [13/59] compared with 5% [2/38], p=0.026)[6].

Safety summary

Local arterial dissection

Local arterial dissection was reported in 2% (4/216) of patients who had PAE and in none of the patients who had TURP in a register of 318 patients[7].

Non-target embolisation

Non-target embolisation was reported in 1% (2/216) of patients who had PAE in the register of 318 patients; these were small penile ulcers that resolved within 6 weeks[7]. Seminal vesicle ischaemia was described in 1 patient in a case report. The patient reported a few episodes of haematospermia within the first 3 weeks after the procedure, which had resolved at 1-month follow-up[9].

Bladder wall ischaemia

Bladder wall ischaemia was reported in 1 patient in a case series of 630 patients[5]. This was successfully treated by surgery. Bladder wall ischaemia was reported in less than 1% (2/842) of patients who had PAE in the systematic review of 16 studies[1].

Acute urinary retention

Acute urinary retention was reported in 9% (14/149) of patients who had PAE and 2% (3/148) of patients who had prostatectomy or TURP in the systematic review of 16 studies (p=0.006); it was reported in 11% (94/842) of patients included in non-comparative studies[1]. Acute urinary retention was reported in 2% (11/630) of patients in the case series of 630 patients[5].

Haematuria

Haematuria was reported in 3% (5/149) of patients who had PAE and 3% (5/148) of patients who had prostatectomy or TURP in the systematic review of 16 studies; it was reported in 8% (69/842) of patients included in non-comparative studies[1]. Haematuria was reported in 8% (48/630) of patients in the case series

of 630 patients[5]. It was reported by 19% (37/199) of patients who had PAE and responded to a questionnaire survey, 64% (39/61) of patients who had TURP and 80% (8/10) of patients who had holmium laser enucleation of the prostate, in the register of 318 patients[7].

Haematospermia

Haematospermia was reported in 1 patient each in the PAE and control group in the systematic review of 16 studies; it was reported in 7% (62/842) of patients included in the non-comparative studies[1]. Haematospermia was reported in 7% (46/630) of patients in the case series of 630 patients[5]. It was reported by 13% (25/199) of patients who had PAE and responded to a questionnaire survey, 2% (1/61) of patients who had TURP and none of the 10 patients who had holmium laser enucleation of the prostate, in the register of 318 patients[7].

Abnormal ejaculation

Abnormal ejaculation was reported in 1% (2/149) of patients who had PAE and 10% (15/148) of patients who had prostatectomy or TURP in the systematic review of 16 studies ($p=0.001$)[1]. Retrograde ejaculation was reported by 24% (48/199) of patients who had PAE and responded to a questionnaire survey, 48% (29/61) of patients who had TURP and 40% (4/10) of patients who had holmium laser enucleation of the prostate, in the register of 318 patients[7].

Rectal bleeding

Rectal bleeding was reported in 6% (34/630) of patients in the case series of 630 patients[5].

Inguinal haematoma

Inguinal haematoma was reported in 2% (12/630) of patients in the case series of 630 patients[5]. It was reported in 3% (21/842) of patients who had PAE in the systematic review of 16 studies[1]. Haematoma was reported in 2% (4/216) of patients who had PAE and in none of the patients who had TURP in the register of 318 patients[7].

Anaemia

Anaemia was reported in 3% (5/149) of patients who had PAE and in none of the patients who had prostatectomy or TURP in the systematic review of 16 studies[1]. The mean change in haemoglobin was 0.3 g/l in the PAE group and 2.1 g/l in the TURP group in an RCT of 114 patients ($p<0.001$), which was also included in the systematic review[2]. No patients who had PAE needed an intraoperative blood transfusion compared with 2 patients who had prostatectomy or TURP in the same study.

Sepsis

Sepsis was reported in 1 patient (1/216) who had PAE and 2 patients (2/89) who had TURP in the register of 318 patients[7].

Urinary tract infection

Urinary tract infection was reported in 3% (4/149) of patients who had PAE and 2% (3/148) of patients who had prostatectomy or TURP in the systematic review of 16 studies; it was reported in 6% (52/842) of patients included in the non-comparative studies[1]. Urinary tract infection was reported in 5% (27/630) of patients in the case series of 630 patients[5]. It was reported by 5% (10/199) of patients who had PAE and responded to a questionnaire survey, 1 patient who had TURP and 20% (2/10) of patients who had holmium laser enucleation of the prostate, in the register of 318 patients[7].

Dysuria

Dysuria was reported in 24% (152/630) of patients in the case series of 630 patients[5]. It was reported in 2% (17/842) of patients who had PAE in the systematic review of 16 studies. Irritative voiding and urethral burning were reported in 3% (28/842) and 9% (76/842) of patients respectively in the same study.

Urgency or incontinence

Urgency or incontinence was reported in 2% (3/149) of patients who had PAE and 3% (4/148) of patients who had prostatectomy or TURP in the systematic review of 16 studies[1]. Frequency was reported in 23% (145/630) of patients in the case series of 630 patients[5]. Incontinence was reported by 1% (2/199) of patients who had PAE and responded to a questionnaire survey, 3% (2/61) of patients who had TURP and none of the 10 patients who had holmium laser enucleation of the prostate, in the register of 318 patients[7].

Urethral or bladder neck stricture

Urethral or bladder neck stricture was reported in 1% (2/149) of patients who had PAE and in none of the patients who had prostatectomy or TURP in the systematic review of 16 studies. Urethral stricture and bladder neck stenosis were each reported in 1 patient in the control group.

Pain

Persistent perineal pain, lasting 3 months, was reported in 1 patient in a case series of 630 patients[5].

Severe constipation

Obstipation was reported in 13% (76/630) of patients in the case series of 630 patients[5].

Other

Radiodermitis was described in a case report. The patient developed an erythematous lesion in the lower back and sacral area within 12 days of PAE, which was treated with a urea-based lotion for 15 days[8]. After 60 days there was just a small area of skin atrophy. Expulsion of prostatic tissue was described in 1 patient in a case report[10]. The patient had increasing nocturia and urinary frequency in the first 2 weeks after PAE and then expelled a small tissue fragment at the end of the fourth week. Pathological analysis confirmed the microscopic aspects of prostatic tissue with extensive necrosis. The patient no longer had a weak stream, intermittency or nocturia.

Anecdotal and theoretical adverse events

In addition to safety outcomes reported in the literature, specialist advisers are asked about anecdotal adverse events (events which they have heard about) and about theoretical adverse events (events which they think might possibly occur, even if they have never happened). For this procedure, specialist advisers listed the following anecdotal adverse event: retropubic pain that resolves within 1 week. They considered that the following were theoretical adverse events: non-target embolisation to rectum causing significant bowel ischaemia and the procedure affecting interpretation of PSA level.

The evidence assessed

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to prostate artery embolisation for benign prostatic hyperplasia. The following databases were searched, covering the period from their start to 15 August 2017: MEDLINE, PREMEDLINE, EMBASE, Cochrane Library and other databases. Trial registries and the Internet were also searched. No language restriction was applied to the searches (see the end of this document for details of search strategy). Relevant published studies identified during consultation or resolution that are published after this date may also be considered for inclusion.

The following selection criteria (table 1) were applied to the abstracts identified by the literature search. Where selection criteria could not be determined from the abstracts the full paper was retrieved.

Table 1 Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies were included. Emphasis was placed on identifying good quality studies. Abstracts were excluded where no clinical outcomes were reported, or where the paper was a review, editorial, or a laboratory or animal study. Conference abstracts were also excluded because of the difficulty of appraising study methodology, unless they reported specific adverse events that were not available in the published literature.
Patient	Patients with benign prostatic hyperplasia.
Intervention/test	Prostate artery embolisation.
Outcome	Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy.
Language	Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base.

List of studies included in the IP overview

This IP overview is based on approximately 1,600 patients who had prostate artery embolisation from 1 systematic review, 2 randomised controlled trials (also included in the systematic review), 1 non-randomised comparative study (also included in the systematic review), 2 case series, 1 register, and 3 case reports[1-10] . There is some patient overlap between the studies.

Other studies that were considered to be relevant to the procedure but were not included in the main extraction table (table 2) have been listed towards the end of this document.

Table 2 Summary of key efficacy and safety findings on prostate artery embolisation for benign prostatic hyperplasia

Study 1 Shim SR (2017)

Details

Study type	**Systematic review and meta-analysis**
Country	Brazil, China, France, Italy, Portugal, Russia, US
Recruitment period	Search date: January 2016
Study population and number	**n=1047** (899 prostate artery embolisation, 148 control); 16 studies (3 comparative) Patients with benign prostatic hyperplasia (BPH)
Age	Mean age ranged from 63.5 to 74.5 years
Patient selection criteria	Study inclusion criteria were: interventions included prostate artery embolisation, patients were diagnosed with BPH, and reasonable intention-to-treat analysis was done in randomised controlled trials and comparative trials. Retrospective studies were excluded. Two people screened the titles and abstracts of all articles using predefined inclusion and exclusion criteria (not further described).
Technique	For PAE, polyvinyl alcohol particle size was 50 to 500µm. Catheterisation was bilateral in 2 studies and unilateral or bilateral in 13 studies (not reported in 1 study). Comparative procedures were open prostatectomy (1 study, n=80) and transurethral resection of the prostate (2 studies, n=68).
Follow-up	**1 to 36 months**
Conflict of interest/source of funding	None for authors of systematic review.

Analysis

Study design issues: The systematic review and meta-analysis were done according to the standard PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol and the Cochrane collaboration. Only 3 of the included studies were comparative. All studies described reasonable intention-to-treat analysis and had no selective reporting bias. The randomised controlled trials did not describe double blinding. The primary outcome was the change in BPH measured by the International Prostate Symptom Score (I-PSS). Secondary outcomes included quality of life, maximal urinary flow (Qmax), prostate volume, post-void residual volume, International Index of Erectile Function (IIEF), prostate-specific antigen (PSA) and adverse events. Statistical heterogeneity was not reported. Meta-regression analysis was done for each potential moderator (number of patients, country, catheterisation type and polyvinyl alcohol particle size).

Key efficacy and safety findings

Efficacy

Number of patients analysed: **1047** (899 prostate artery embolisation [PAE], 80 open prostatectomy, 68 transurethral resection of the prostate [TURP])

Comparative studies (n=3 studies)

Pooled overall standardised mean differences in the mean change from baseline for the PAE versus the control group (total of 3 studies, although some measures collected in just 2 studies)

- I-PSS=0.88 (95% CI 0.10 to 1.66)
- Q_{max}=-1.44 (95% CI -2.30 to -0.58)
- Prostate volume=0.48 (95% CI 0.14 to 0.82)
- Quality of life=0.25 (95% CI -0.28 to 0.77)
- Post-void residual volume=0.14 (95% -0.18 to 0.46)
- IIEF=0.05 (95% CI -1.52 to 1.62)
- PSA=0.46 (95% CI -0.02 to 0.95)

The differences in I-PSS, Qmax, and prostate volume were statistically significantly lower in the PAE group compared with the control group (i.e. favouring the control). There were no statistically significant differences in the other outcome measures.

Non-comparative studies (n=13 studies)

Pooled overall weighted mean differences in mean change from baseline for PAE

- I-PSS=-12.77 (95% CI -15.04 to -10.50)
- Q_{max}=5.29 (95% CI 4.35 to 6.23)
- Prostate volume=-29.79 (95% CI -36.99 to -22.58)
- Quality of life=-2.34 (95% CI -2.72 to -1.97)
- Post-void residual volume=-66.89 (95% -77.09 to -56.68)
- IIEF=1.31 (95% CI 0.82 to 1.81)
- PSA=-0.78 (95% CI -1.86 to 0.30)

All outcomes except PSA were statistically significantly improved from baseline.

Improvement rate ranges from baseline after PAE

- I-PSS=31.0% to 85.2%
- Q_{max}=16.5% to 132.0%
- Prostate volume=4.5% to 44.9%
- Quality of life=28.7% to 81.3%
- Post-void residual volume=35.0% to 75.6%
- IIEF=0% to 18.2%
- PSA=0% to 81.0%

Safety

One of the 16 studies did not describe adverse events.

Adverse events in PAE and control groups, n (%)

Adverse event	Comparative studies			Non-comparative studies
	PAE n=149	Control n=148	p value	PAE n=842
Any	62 (41.6)	45 (30.4)	0.044	485 (57.6)
Haematuria	5 (3.4)	5 (3.4)	1.00	69 (8.2)
Haemospermia	1 (0.7)	1 (0.7)	1.00	62 (7.4)
Acute urinary retention	14 (9.4)	3 (2.0)	0.006	94 (11.2)
Urgency or incontinence	3 (2.0)	4 (2.7)	0.723	-
Urinary tract infection	4 (2.7)	3 (2.0)	1.00	52 (6.2)
Recurrent lower urinary tract symptoms	2 (1.3)	0	0.498	-
Anaemia	5 (3.4)	0	0.06	-
Technical failure	3 (2.0)	0	0.247	-
Urethral/bladder neck stricture	2 (1.3)	0	0.498	-
Rectal bleeding	1 (0.7)	0	1.00	39 (4.6)
Abnormal ejaculation	2 (1.3)	15 (10.1)	0.001	-
Transient pubic bone ischaemia	1 (0.7)	0	1.00	-
Post-embolisation syndrome	6 (4.0)	0	0.03	-
Pelvic pain	1 (0.7)	0	1.00	-
Clinical failure	5 (3.4)	2 (1.4)	0.448	-
Intraoperative damage to venous sinus and rupture	0	1 (0.7)	0.498	-
Urethral stricture	0	1 (0.7)	0.498	-
Intraoperative blood transfusion	0	2 (1.4)	0.247	-
TURP syndrome	0	1 (0.7)	0.498	-
Clot retention	0	1 (0.7)	0.498	-
Bladder neck stenosis	0	1 (0.7)	0.498	-
Others	7 (4.7)	5 (3.4)	0.564	-
Inguinal haematoma	-	-	-	21 (2.5)
Dysuria	-	-	-	17 (2.0)
Irritative voiding	-	-	-	28 (3.3)
Urethral burning	-	-	-	76 (9.0)

	Balanoprostatitis	-	-	-	4 (0.5)
	Bladder wall ischaemia	-	-	-	2 (0.2)
	Small rectorrhagia	-	-	-	6 (0.7)
	Balanitis	-	-	-	4 (0.5)
	Frequency	-	-	-	8 (1.0)
	Diarrhoea	-	-	-	2 (0.2)
	Ischaemia	-	-	-	1 (0.1)

The authors also noted that PAE involves 18 to 55 minutes of radiation exposure.

Abbreviations used: CI, confidence interval; IIEF, International Index of Erectile Function; I-PSS, International Prostate Symptom Score; PAE, prostate artery embolisation; PSA, prostate specific antigen; Q_{max}, maximal urinary flow; TURP, transurethral resection of the prostate

Study 2 Gao Y (2014) – also included in the systematic review by Shim SR et al. (study 1)

Details

Study type	**Randomised controlled trial**
Country	China
Recruitment period	2007 to 2012
Study population and number	**n=114** (57 prostate artery embolisation [PAE], 57 transurethral resection of the prostate [TURP]) Patients with lower urinary tract symptoms caused by benign prostatic hyperplasia
Age	PAE: mean 68 years TURP: mean 66 years, p=0.397
Patient selection criteria	Inclusion criteria: International Prostate Symptom Score (IPSS) greater than 7 after failed medical therapy with a washout period of 2 or more weeks, prostate volume 20 to 100 ml on transrectal ultrasound or MRI images, peak urinary flow less than 15 ml/sec. Exclusion criteria: detrusor hyperactivity or hypocontractility at urodynamic study, urethral stricture, prostate cancer, diabetes mellitus, and previous prostate, bladder neck or urethral surgery. Patients with a prostate-specific antigen (PSA) value greater than 4 ng/ml or an abnormal finding at digital rectal examination had ultrasound-guided prostate biopsy before study inclusion. These patients were included in the study if the biopsy result was negative.
Technique	PAE was done bilaterally or unilaterally depending on whether a catheter could be inserted in the prostatic arteries, using local anaesthesia. Polyvinyl alcohol microspheres (355 to 500 µm in diameter; Cook) were used for embolisation. TURP was done using epidural anaesthesia.
Follow-up	**Mean 22.5 months**
Conflict of interest/source of funding	None

Analysis

Follow-up issues: 5 patients were lost to follow-up (2 in the PAE group and 3 in the TURP group). Results for patients who were lost to final follow-up at 24 months were included in the analysis, when available.

Study design issues: Patients were randomly assigned to a treatment group using computer generated simple random tables. The minimum sample size to detect statistically significant differences was reported to be 50 patients per group. All randomly assigned patients who did not withdraw from the study were included on a modified intention-to-treat basis. Observers were not blinded to group assignment.

Study population issues: There were no statistically significant differences in baseline characteristics between the 2 treatment groups.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **114 (57 versus 57)**

Technical Success

- PAE=94.7% (54/57); PAE was done bilaterally in 48 patients and unilaterally in 6 patients. It was not possible in 3 patients because of tortuosity and atherosclerotic changes of the bilateral iliac arteries.
- TURP=100% (53/53)

Clinical failure (defined as persisting severe symptoms after the procedure)

- PAE=9.4% (5/57); all 5 patients had a hypovascular or complicated blood supply pattern without a predominant prostatic artery.
- TURP=3.8% (2/53)

Intraoperative and early postoperative outcomes (± sd)

Outcome	PAE (n=54)	TURP (n=53)	p value
Procedure time (min)	89.7±17.1	83.5±17.5	0.066
Fluoroscopy time (min)	33.2±6.7	0	<0.001
Mean change in serum sodium level (mmol/l)	1.4±1.2	2.7±2.2	<0.001
Mean change in haemoglobin level (g/l)	0.3±0.2	2.1±0.7	<0.001
Urethral catheter (n)	19 (35.2%)	53 (100%)	<0.001
Hospital admission (n)	26 (48.1%)	53 (100%)	<0.001
Length of stay (d)	2.9±1.6	4.8±1.8	<0.001

Mean IPSS Score (range 0 [best] to 35 [worst])

Follow-up	PAE (n=54)	TURP (n=53)	p value
Baseline	24.7	24.3	-
1 month	19.2	13.7	0.0001
3 months	15.6	11.0	0.0001
6 months	12.8	11.3	-
12 months	10.9	10.2	-
24 months	8.7	8.4	-
p value	0.001	0.001	

Mean Quality of Life Score (range 0 [delighted] to 6 [terrible]

Follow-up	PAE (n=54)	TURP (n=53)	p value
Baseline	4.8	4.6	-
1 month	3.7	2.8	0.0001
3 months	2.9	2.3	0.0001
6 months	2.2	2.3	-
12 months	1.9	1.8	-
24 months	1.6	1.4	-
p value	0.001	0.001	

Safety

Adverse events and complications

Adverse event or complication	PAE	TURP	Management	p value
Intraoperative				
Blood transfusion	0	2 (3.8%)	Transfusion	0.444
Transurethral resection syndrome	0	1 (1.9%)	Admission to intensive care unit	0.971
Early (<30 days)				
Postembolisation syndrome	6 (11.1%)	0	Symptomatic treatment	0.038
Severe pelvic pain	1 (1.9%)	0	Narcotics and antibiotics	>0.99
Acute urinary retention	14 (25.9%)	3 (5.7%)	Bedside recatheterisation	0.004
Haematuria	0	4 (7.5%)	Bladder irrigation	0.122
Urinary tract infection	1 (1.9%)	2 (3.8%)	Antibiotics	0.987
Clot retention	0	1 (1.9%)	Bedside catheter change	0.993
Late (≤24 months)				
Urethral stricture	0	1 (2.1%)	Dilatation	>0.99
Bladder neck stenosis	0	1 (2.1%)	Bladder neck incision	>0.99
Overall adverse events or complications (including technical and clinical failure)				
Minor (Clavien grades I and II)	22 (38.6%)	13 (22.8%)		0.113
Major (Clavien grades III and IV)	8 (14%)	4 (7%)		0.275
Total	30 (52.6%)	17 (29.8%)		0.029

The authors noted that postembolisation syndrome and acute urinary retention in the PAE group generally disappeared within 3 postoperative days, were without clinical consequence, and occurred with sufficiently high frequency that they might be considered expected side effects rather than complications.

The authors noted that the mean radiation dose in the PAE group (11,305 cGy cm^2) was slightly larger than that of a gastrointestinal barium meal used to examine the oesophagus, stomach, and small intestine and was within an acceptable range of radiation dose.

Mean peak urinary flow (ml/s)

Follow-up	PAE (n=54)	TURP (n=53)	p value
Baseline	7.8	7.3	-
1 month	13.1	18.2	0.0001
3 months	17.3	21.4	0.0001
6 months	21.5	23.7	-
12 months	22.1	23.1	-
24 months	21.5	22.1	-
p value	0.001	0.001	

Mean postvoid residual urine (ml)

Follow-up	PAE (n=54)	TURP (n=53)	p value
Baseline	126.9	115.4	-
1 month	88.6	47.5	0.0001
3 months	56.8	33.2	0.0001
6 months	39.2	30.9	-
12 months	27.3	22.3	-
24 months	19.4	15.2	-
p value	0.001	0.001	

PSA levels (ng/ml)

Follow-up	PAE (n=54)	TURP (n=53)	p value
Baseline	3.7	3.6	-
1 month	2.8	1.9	0.0002
3 months	2.2	1.5	0.0012
6 months	2.0	1.7	0.0019
12 months	2.1	1.6	0.0092
24 months	2.1	1.7	0.0116
p value	0.001	0.001	

Mean prostate volume (ml)

Follow-up	PAE (n=54)	TURP (n=53)	p value
Baseline	64.7	63.5	-
1 month	50.1	26.2	0.0001
3 months	43.4	27.3	0.0001
6 months	36.3	26.8	0.0001
12 months	35.6	26.4	0.0001
24 months	34.9	26.6	0.0001
p value	0.001	0.001	

Abbreviations used: I-PSS, International Prostate Symptom Score; PAE, prostate artery embolisation; PSA, prostate specific antigen; sd, standard deviation; TURP, transurethral resection of the prostate

Study 3 Carnevale F (2016) – also included in the systematic review by Shim SR et al. (study 1)

Details

Study type	**Randomised controlled trial**
Country	Brazil
Recruitment period	2010 to 2014
Study population and number	**n=45** (15 original prostate artery embolisation [PAE], 15 PErFecTED [proximal embolisation first, then embolise distal] method of prostate artery embolisation, 15 transurethral resection of the prostate [TURP]) Patients with lower urinary tract symptoms caused by benign prostatic hyperplasia.
Age	PAE: mean 64 years PErFecTED PAE: mean 60 years TURP: mean 66 years, p=0.06
Patient selection criteria	Inclusion criteria included: age >45 years; International Prostate Symptom Score (IPSS) >19; symptoms refractory to medical treatment for at least 6 months; negative screening for prostate cancer; prostate volume between 30 and 90 cm^3 on MRI; and bladder outlet obstruction confirmed by urodynamic examination. Exclusion criteria included renal failure, bladder calculi or diverticula, suspected prostate cancer, urethral stenosis, and neurogenic bladder disorders.
Technique	PAE procedures were done under local anaesthesia, through a unilateral femoral artery approach on an outpatient basis. Calibrated 300 to 500 µm tris-acryl gelatin microspheres (Embosphere Microspheres; Merit Medical, USA) were used for embolisation. Embolisation was done on both sides using the same technique. TURP was done under spinal anaesthesia, using a resectoscope and monopolar generator.
Follow-up	**12 months**
Conflict of interest/source of funding	None

Analysis

Follow-up issues: There were no losses to follow-up.

Study design issues: 15 patients were randomised to each arm of the original PAE versus TURP study. An additional 15 patients who had the PErFecTED method of PAE were enrolled in a separate arm.

Study population issues: Baseline characteristics were similar across all study groups except for IIEF, Q_{max}, and bladder contractility. Patients in the PErFecTED group had statistically significantly higher IIEF scores than those in the TURP group (p=0.015). Patients in both PAE groups had statistically significantly lower baseline Q_{max} than patients in the TURP arm (p=0.004 across all 3 groups). All patients in the TURP group had normal bladder contractility, but the prevalence of hypocontractile and borderline bladders were 33% (5/15) and 67% (10/15) in the original PAE group and 53% (8/15) and 40% (6/15) in the PErFecTED group respectively (p=0.0001).

Other issues: there is some patient overlap with study 6 (Carnevale F et al., 2017).

Key efficacy and safety findings

<table>
<tr><th>Efficacy</th><th>Safety</th></tr>
<tr><td>
Number of patients analysed: 45 (15 versus 15 versus 15)

87% (13/15) of patients in the original PAE group had successful bilateral embolisation; 2 patients had unilateral embolisation because of severe atherosclerosis or occlusion of the inferior vesical artery on 1 side. All patients in the PErFecTED group had bilateral embolisation.

Procedure characteristics
<table>
<tr><th>Procedure</th><th>Mean procedure time (min)</th><th>Mean fluoroscopy time (min)</th></tr>
<tr><td>Original PAE</td><td>144.8±50.1</td><td>49.2±17.2</td></tr>
<tr><td>PErFecTED PAE</td><td>147.5±30.4</td><td>45.8±14.6</td></tr>
<tr><td>TURP</td><td>61.7±17.0</td><td>N/A</td></tr>
</table>
Mean clinical and urodynamic characteristics at 24 month follow-up
<table>
<tr><th>Variable</th><th>Original PAE</th><th>PErFecTED PAE</th><th>TURP</th></tr>
<tr><td>IPSS</td><td>12.8±8.0*</td><td>3.6±2.9*</td><td>6.1±8.6*</td></tr>
<tr><td>Quality of life</td><td>2.2±1.2*</td><td>1.6±0.7*</td><td>0.9±1.4*</td></tr>
<tr><td>IIEF</td><td>12.6±7.7</td><td>18.7±3.2</td><td>16.1±5.7*</td></tr>
<tr><td>Prostate volume (cm^3)</td><td>50.9±19.0*</td><td>50.0±13.8*</td><td>32.0±11.4*</td></tr>
<tr><td>PSA (ng/ml)</td><td>2.2±1.1</td><td>1.7±1.2*</td><td>1.6±0.9*</td></tr>
<tr><td>Post-void residual urine volume (ml)</td><td>62.3±71.0*</td><td>48.6±65.7</td><td>8.3±11.9*</td></tr>
<tr><td>Q_{max} (ml/sec)</td><td>10.1±6.5*</td><td>16.7±8.4*</td><td>27.1±8.7*</td></tr>
</table>
* statistically significant change from baseline

Recurrence of lower urinary tract symptoms

Original PAE=13.3% (2/15) (1 at 6 and 1 at 12 month follow-up; both patients subsequently had successful TURP)
PErFecTED PAE=0% (0/15)
TURP=0% (0/15)

</td><td>
Patients who had PAE reported local pain at the prostate site, mild to moderate urethral burning during voiding, and urinary frequency for 3 to 4 days after the procedure.

Other adverse events occurring in PAE groups:

Transient minimal rectal bleeding=6.7% (1/15 in each group)
Haematospermia=6.7% (1/15 in each group)
Reduction in ejaculate volume=13.3% (2/15 in original PAE group) and 6.7% (1/15 in PErFecTED group)
Transient pubic bone ischaemia=6.7% (1/15 in original PAE group)
Haematuria=13.3% (2/15 in original PAE group)

All patients who had TURP reported pollakuria, dysuria and haematuria for up to 2 weeks after the procedure.

Other adverse events in TURP group:

Intraoperative damage to the left venous sinus and rupture of the prostatic capsule=6.7% (1/15; treated successfully with Foley balloon traction for 2 hours after resection to stop bleeding)
Haematuria needing readmission for bladder catheterisation and temporary irrigation=6.7% (1/15; occurred 24 hours after discharge)
Early urinary incontinence=26.7% (4/15)
Retrograde ejaculation=100% (15/15)

Prostate cancer was diagnosed incidentally in 1 patient in the TURP group during histopathological examination of resected tissue.
</td></tr>
<tr><td colspan="2">Abbreviations used: IIEF, International Index of Erectile Function; IPSS, International Prostate Symptom Score; PAE, prostate artery embolisation; PErFecTED, proximal embolisation first then embolise distal; PSA, prostate specific antigen; Q_{max}, maximal urinary flow; TURP, transurethral resection of the prostate</td></tr>
</table>

Study 4 Russo GI (2015) – also included in the systematic review by Shim SR et al. (study 1)

Details

Study type	**Matched pair analysis**
Country	Italy, Russia
Recruitment period	2006 to 2014
Study population and number	**n=160** (80 prostate artery embolisation [PAE], 80 open prostatectomy) Patients with lower urinary tract symptoms caused by benign prostatic obstruction
Age	PAE: mean 67 years Prostatectomy: mean 68 years, p=0.19
Patient selection criteria	Inclusion criteria: symptomatic benign prostatic obstruction, International Prostate Symptom Score (IPSS) ≥12, prostate-specific antigen (PSA) level <4 ng/ml or between 4 and 10 ng/ml but negative prostate biopsy, prostate volume >80 cm^3, and Q_{max} <15 ml/sec. Exclusion criteria: neurogenic bladder dysfunction or sphincter decompensation, coagulation disorders or antiplatelet or anticoagulant therapy, chronic kidney disease, previous surgical treatment for lower urinary tract symptoms caused by benign prostatic obstruction or therapy with 5-alpha reductase inhibitors, life expectancy <2 years, current diagnosis of bladder stones, and patients with a catheter or an episode of acute retention of urine in the last 4 weeks.
Technique	Trisacryl microspheres (Embosphere Microspheres, Biosphere Medical, France) 300 to 500 µm in diameter were used for embolisation. Embolisation was done on both sides using the same technique.
Follow-up	**1 year**
Conflict of interest/source of funding	None

Analysis

Follow-up issues: Of all 287 consecutive patients treated during the study period, 6.3% (18/287) were lost to follow-up and 28.6% (82/287) were excluded by the matched-pair comparison.

Study design issues: The 2 procedures were done at 2 different centres in different countries. Propensity score matching was done to adjust for preoperative variables (IPSS, peak flow, post-void residual, and prostate volume) and a 1:1 matched pair comparison was done. Primary endpoints were the comparison regarding IPSS, IIEF-5, peak flow, post-void residual and IPSS quality of life after 1 year follow-up. Secondary endpoints were the comparison regarding postoperative haemoglobin level, duration of catheterisation, duration of hospitalisation, and complications.

Study population issues: The 2 treatment groups were comparable with regard to all reported baseline characteristics.

Key efficacy and safety findings

Efficacy

Number of patients analysed: **160 (80 versus 80)**

Median operative time (minutes)

- PAE=57 (range 42 to 74)
- Prostatectomy=84 (range 68 to 101), p<0.05

Mean IPSS Score (lower scores better)

Follow-up	PAE (n=80)	Prostatectomy (n=80)	p value
Baseline	24.0	23.4	-
1 month	12.2	6.1	-
6 months	11.4	4.9	-
12 months	10.4	4.3	<0.05
p value	<0.01	<0.01	

Mean peak flow (ml/sec)

Follow-up	PAE (n=80)	Prostatectomy (n=80)	p value
Baseline	7.3	7.9	-
1 month	15.0	22.9	-
6 months	16.2	24.5	-
12 months	16.9	23.8	<0.05
p value	<0.01	<0.01	

Mean post-void residual (ml)

Follow-up	PAE (n=80)	Prostatectomy (n=80)	p value
Baseline	62.3	65.0	-
1 month	19.8	13.8	-
6 months	19.2	4.3	-
12 months	18.4	6.2	<0.05
p value	<0.01	<0.01	

Mean PSA (ng/ml)

Follow-up	PAE (n=80)	Prostatectomy (n=80)	p value
Baseline	3.6	4.2	-
1 month	2.6	1.0	-
6 months	2.4	1.4	-
12 months	2.1	1.3	<0.05
p value	<0.01	<0.01	

Mean IIEF-5 (higher scores better)

Follow-up	PAE (n=80)	Prostatectomy (n=80)	p value
Baseline	14.4	15.1	-
1 month	15.5	9.6	-
6 months	15.5	10.7	-
12 months	15.1	10.9	<0.05
p value	<0.01	<0.01	

Mean postoperative haemoglobin levels (mg/dl)

- PAE=14.5
- Prostatectomy=11.5, p<0.05

Mean length of hospitalisation (days)

- PAE=2.5
- Prostatectomy=9.2, p<0.05

Safety

Complications

	PAE	Prostatectomy
Grade 1	**6 (7.5%)**	**11 (13.75%)**
Haematuria or clots needing catheter irrigation	0	4
Urgency or incontinence (needing anticholinergics)	0	2
Haematospermia	1	0
Others*	5	5
Grade 2	**1 (1.3%)**	**10 (12.5%)**
Urinary tract infection (needing antibiotics)	1	3
Anaemia (needing transfusions)	0	5
Others	0	2
Grade 3a	**0 (0%)**	**3 (3.8%)**
Urethral or bladder neck stricture (needing endoscopy)	0	2
Urgency or incontinence (needing anticholinergics)	0	1
Overall	**7 (8.8%)**	**25 (31.3%)**

*Other Grade 1 complications included pain, fever, wound discharge, anastomotic leakage, and stress incontinence.

Mean length of catheterisation (days) • PAE=0.03 • Prostatectomy=6.1, p<0.05 Multivariate logistic regression, adjusted for preoperative and perioperative variables, showed that PAE was significantly associated with persistent symptoms after 1 year (IPSS ≥8; odds ratio 2.67; 95% confidence interval [CI] 0.96 to 7.4, p<0.01) and 1-year persistent peak flow ≤15 ml/sec (odds ratio 4.95; 95% CI 1.73 to 14.15, p<0.05). No patient in either group needed repeat surgery because of recurrence of benign prostatic obstruction.	
Abbreviations used: CI, confidence interval; IIEF, International Index of Erectile Function; IPSS, International Prostate Symptom Score; PAE, prostate artery embolisation; PSA, prostate specific antigen	

Study 5 Pisco JM (2016)

Details

Study type	**Case series**
Country	Portugal
Recruitment period	2009 to 2014
Study population and number	**n=630** Patients with moderate to severe lower urinary tract symptoms associated with benign prostatic hyperplasia.
Age	Mean 65 years (range 40 to 89)
Patient selection criteria	Inclusion criteria: age over 40 years, a diagnosis of benign prostatic hyperplasia with moderate to severe lower urinary tract symptoms (IPSS ≥18 and quality of life ≥3), Q_{max} ≤12 ml/sec or acute urinary retention, refractory to medical or other treatment for at least 6 months, prostate volume >30 ml, and acceptance of the risk of sexual dysfunction after the treatment. Patients with prostate volume below 30 ml were included if the urodynamic study showed infravesical obstruction. Exclusion criteria included malignancy, advanced atherosclerosis and tortuosity of the iliac or prostatic arteries on CT angiography, secondary renal insufficiency, large bladder diverticula or stones, neurogenic bladder, detrusor failure, active urinary tract infection, and unregulated and uncontrollable coagulation parameters.
Technique	All procedures were done under local anaesthesia on an outpatient basis. A unilateral approach was used when possible, usually through the right femoral artery. If the iliac arteries were very tortuous, a bilateral femoral approach was used. Embolisation was done using 100 µm or 200 µm nonspherical PVA particles (Cook Inc.) in 418 patients, 300 to 500 µm spherical PVA particles (Bead Block, Biocompatibles UK Ltd., UK) in 167 patients, and 400 µm Polyzene-coated hydrogel microspheres (Embozene, CeloNova BioSciences Inc., US) in 33 patients. Embolisation was done on both sides using the same technique.
Follow-up	**Median 24 months (range 12 to 78)**
Conflict of interest/source of funding	None

Analysis

Follow-up issues: Among the 618 patients in whom prostate artery embolisation was technically successful, 47 (7.6%) were lost to follow-up before any evaluation could be done. Outcome parameters were measured at baseline; 1, 3 and 6 months; every 6 months between 1 and 3 years; and yearly thereafter up to 6.5 years.

Study design issues: Single centre, retrospective cohort study with consecutive patients.

Study population issues: 10.6% (67/630) of patients had acute urinary retention at baseline.

Other issues: The short term and medium term results of the first 225 patients in this series were previously published in 3 reports that were included in the systematic review by Shim SR et al. (study 1).

Key efficacy and safety findings

Efficacy

Number of patients analysed: **630**

Technical success (defined as selective prostatic arterial catheterisation and embolisation on at least 1 side)=98.1% (618/630); 92.6% (572/618) bilateral, 7.4% (46/618) unilateral

Mean procedure time=77 mins (range 16 to 258)
Mean fluoroscopy time=19.5 mins (range 4.9 to 91)
Mean dose area product=2,415 Gy/cm^3 (range 625 to 9,503)

There were no statistically significant differences in procedure and fluoroscopy times or radiation dose between the different embolic agents used.

Mean procedure pain score (VAS, 0 to 10)

- During PAE=1.6 (range 0 to 9); 85.2% (537/630) of patients did not feel any pain.
- At discharge=0.4 (range 0 to 5)

Immediate improvement of lower urinary tract symptoms=34.6% (218/630)
Of the 67 patients with acute urinary retention, 60 (95.3%) had the bladder catheter removed and were able to spontaneously void between 2 days and 3 months after the procedure.

Cumulative clinical success over time (defined as improved symptoms [IPSS ≤15 points and a decrease of at least 25% from baseline], improved QoL [QoL score ≤3 points or a decrease of at least 1 point from baseline], and no need of any medical or other therapy after PAE)

Month	At risk	% clinical success	95% CI	
1	571	91.2	88.6	93.3
6	513	87.7	84.8	90.2
12	496	85.1	81.9	87.8
24	343	81.9	78.3	84.9
36	232	80.8	77.1	84.0
48	103	80.8	77.1	84.0
60	36	76.3	68.6	82.4
78	8	76.3	68.6	82.4

There were 104 (18%) clinical failures: 85 (82.5%) at short-term (up to 1 year after PAE), 14 at medium-term (1 to 3 years after PAE) and 5 at long-term follow-up. Of the 85 short-term clinical failures, 50 (55%) were within 1 month, 7 recurrences occurred at 3 months, 13 at 6 months, and 15 recurrences occurred at 12 months.

Mean changes from baseline for the 328 patients with complete data at 36 months

- IPSS improvement (points)=12.1±8.6, p<0.0001
- QoL improvement (points)=1.69±1.34, p<0.0001
- Reduction in prostate volume (cm^3)=14.0±27.3 (12.6%±26.9), p<0.0001
- PSA reduction (ng/ml)=1.34±5.89, p<0.0001
- Improvement in Q_{max} (ml/min)=3.21±10.3, p<0.0001
- Post-void residual reduction (ml)=37.4±82.7, p<0.0001
- IIEF improvement (points)=1.17±5.74, p=0.0003

IIEF improved or stayed the same in 63.5% of patients.

Safety

PAE-related adverse events

Adverse event	No. of patients	%
Major		
Bladder wall ischaemia	1	0.2
Persistent perineal pain (lasting 3 months)	1	0.2
Minor		
Dysuria	152	24.1
Frequency	145	23.0
Obstipation	76	13.3
Haematuria	48	7.6
Haemato-spermia	46	7.3*
Rectal bleeding	34	5.9
Urinary tract infection	27	4.7
Acute urinary retention	11	1.9
Inguinal haematoma	12	1.9
Balanitis	4	0.7

* reported as 8.0% in the publication

The bladder wall ischaemia was successfully treated by surgery.

Five patients died from unrelated causes and 1 patient had a stroke during follow-up (none of the events were related to the procedure).

The wives of 6 patients conceived and delivered live newborns. They were unable to conceive before PAE, possibly as a result of retrograde ejaculation caused by medication.	
Abbreviations used: CI, confidence interval; IIEF, International Index of Erectile Function; IPSS, International Prostate Symptom Score; PAE, prostate artery embolisation; PSA, prostate-specific antigen; Q_{max}, maximal urinary flow; QoL, quality of life	

Study 6 Carnevale FC (2017)

Details

Study type	**Case series**
Country	Brazil
Recruitment period	2008 to 2013
Study population and number	**n=97** (59 original prostate artery embolisation [PAE], 38 'Proximal embolisation first, then embolise distal' [PErFecTED] PAE) Patients with benign prostatic hyperplasia (BPH).
Age	• Original PAE without recurrence (n=46): mean 65 years • Original PAE with recurrence (n=13): mean 63 years • PErFecTED PAE without recurrence (n=36): mean 63 years • PErFecTED PAE with recurrence (n=2): mean 60 years
Patient selection criteria	Age>45 years, prostate size greater than 30 cm^3, IPSS≥8, quality of life (QoL) score≥3, medical management contraindicated, not tolerated or refused or symptoms refractory to medical therapies. Exclusion criteria included biopsy-proven prostate cancer, active prostatitis or urinary tract infection, previous surgery or other invasive treatment for BPH, any disorder impacting bladder function, or inability to undergo MRI.
Technique	All procedures were done under local anaesthesia. Between June 2008 and February 2013 all procedures were done according to the original PAE method; after March 2013 all PAEs were done according to the PErFecTED technique. 100 to 300 µm or 300 to 500 µm tris-acryl gelatin microspheres (Embosphere Microspheres, Merit Medical Systems, Utah).
Follow-up	**12 months**
Conflict of interest/source of funding	Merit Medical Systems, Inc. provided research grant funding to support the first 11 patients treated at the centre. Three authors are research consultants to Merit Medical Systems, Inc., 1 author also receives patent royalties and 1 has also received research grants from the company (not associated with this project).

Analysis

Follow-up issues: Of the 105 consecutive patients treated at the centre, 97 (92.4%) had 12-month IPSS and QoL data and were included in the final recurrence analyses.

Study design issues: Prospective, single-centre study. The primary endpoint was reduction in International Prostate Symptom Score (IPSS). Patients were categorised into groups based on their PAE treatment method and recurrence status. Clinical success was defined as removal of the Foley catheter in patients with urinary retention, IPSS<8 and QoL<3 at 12 months, with no relevant adverse events from the procedure. Recurrence was defined as IPSS≥8 or QoL≥3 at 12 months.

Other issues: there is some patient overlap with study 3 (Carnevale F et al., 2016).

Key efficacy and safety findings

Efficacy

Number of patients analysed: **97**

The only statistically significant differences in baseline characteristics between recurrent and non-recurrent patients were in the original PAE cohort: recurrent patients had significantly smaller mean prostate sizes (61.1±24.7 cm^3 versus 93.7±40.8 cm^3, p=0.0036), higher mean IPSS (25.7±3.7 versus 21.5±4.7, p=0.0095) and lower mean PSA values (2.7±1.6 ng/ml versus 7.2±5.4 ng/ml, p=0.0003).

Recurrence was statistically significantly more common in the original PAE cohort compared with the PErFecTED cohort (22.0% [13/59] versus 5.3% [2/38], p=0.026).

Unilateral PAE was statistically significantly more common in patients with recurrent symptoms who had original PAE than those who did not have recurrence (23.1% [3/13] versus 4.3% [2/46], p=0.032).

Mean IPSS at 12 month follow-up

- Original PAE=6.0±6.4
- PErFecTED PAE=3.3±2.8, p=0.20

Mean IPSS reduction at 12 month follow-up

- Original PAE=72.5±26.1%
- PErFecTED PAE=83.1±16.0%, p=0.20

Outcomes by PAE method and recurrence status – 12 month follow-up

Variable	Original PAE without recurrence n=46	Original PAE with recurrence n=13	p value	PErFecTED PAE without recurrence n=36	PErFecTED PAE with recurrence n=2	p value
IPSS	3.1±2.2	16.3±5.9	<0.0001	2.9±2.1	11.0±2.8*	0.017
IPSS reduction (%)	84.7±12.5	32.6±7.4	<0.0001	85.7±10.4	37.9±34.8	0.022
QoL	1.0±0.6	3.0±0.8	<0.0001	1.3±0.6	3.5±2.1*	0.04
Prostate size (cm^3)	67.4±31.1	57.0±26.8	>0.20	70.7±32.3	70.1±34.6*	>0.20
Prostate size reduction (%)	28.3±17.3	8.5±15.7	0.0013	24.3±17.9	-1.3±12.9	0.064
PSA (ng/ml)	3.0±1.9	2.8±1.7*	>0.20	2.5±1.7	6.0±2.1*	0.04
Q_{max} (ml/sec)	15.8±6.8	7.7±3.4	0.0002	15.9±7.9	20.2±15.4*	>0.20

* Not statistically significant compared to baseline; all unmarked values are statistically significant compared to baseline

Safety

Adverse events by PAE method

Event	Original PAE (n=59)	PErFecTED PAE (n=38)	p value
Urethral burning	44 (74.6%)	37 (97.4%)	0.003
Decreased ejaculatory volume	10 (17.0%)	4 (10.5%)	>0.20
Retropubic pain	8 (13.6%)	0 (0%)	0.018
Anal burning	8 (13.6%)	0 (0%)	0.018
Transient haematochezia	8 (13.6%)	1 (2.6%)	0.07
Transient haematuria	5 (8.5%)	1 (2.6%)	>0.20
Fever	4 (6.8%)	0 (0%)	0.101
Transient haematospermia	3 (5.1%)	2 (5.3%)	>0.20
Diarrhoea	2 (3.4%)	0 (0%)	>0.20
Trauma during Foley catheter placement	1 (1.7%)	1 (2.6%)	>0.20
Pubic bone ischaemia	1 (1.7%)	0 (0%)	>0.20

Abbreviations used: IPSS, International Prostate Symptom Score; PAE, prostate artery embolisation; PErFecTED, Proximal embolisation first, then embolise distal; PSA, prostate specific antigen; Q_{max}, maximal urinary flow; QoL, quality of life.

Study 7 Ray A (2017)

Details

Study type	**Register (UK ROPE register): part-funded by NICE to inform the review of guidance on this procedure. The safety data is presented here. An efficacy analysis was also undertaken which is currently under peer-review with a journal but is not presented here.**
Country	UK
Recruitment period	2014 to 2016
Study population and number	**n=318** (216 prostate artery embolisation [PAE], 89 transurethral resection of the prostate [TURP] and 13 (holmium laser enucleation of the prostate [HoLEP]). Patients with benign prostatic hyperplasia (BPH).
Age	• PAE: mean 66 years • TURP: mean 70 years, p<0.001 for PAE versus TURP • HoLEP: mean 70 years
Patient selection criteria	Inclusion criteria: Men with lower urinary tract symptoms who have consented for PAE, TURP, open prostatectomy or HoLEP; able to read, write and understand English; capable of giving informed written consent. Exclusion criteria: Not able to read, write or understand English; unable or not willing to provide informed written consent.
Technique	The technique used for PAE is not described in detail.
Follow-up	**12 months**
Conflict of interest/source of funding	This project was part-funded by the National Institute for Health and Care Excellence (NICE). NICE funded an independent academic unit (the Cardiff and Vale UHB/Cardiff University based unit, Cedar) to run the ROPE registry through a competitive tender. The study also received a Research Grant from Cook Medical to fund PAE cases, as well as grants from BSIR and BAUS for the setup of the online register. One author works part-time as a Consultant Clinical Adviser to the NICE Interventional Procedures programme. One author was President of BAUS 2014-2016. One author holds a Consultant Contract with Boston Scientific and has held contracts over the last 2 years with Terumo, Cook Medical and Celonova.

Analysis

Follow-up issues: Follow-up was done in 2 separate ways: at 1, 3, 6 and 12 months, questionnaires were mailed to all patients including International Prostate Symptoms Score (IPSS), International Index of Erectile Function (IIEF) and patient-reported complications. At 3 and 12 months, additional clinical follow-up involved flow studies such as Q_{max}, and a prostate volume study (for PAE patients only). The overall response rate for IPSS in the PAE cohort was 74%.

Study design issues: Multi-centre, single-arm observational study. There was no blinding (either clinician or participant). The main primary outcome was the IPSS improvement in PAE patients at 12 months after the procedure. A clinically important difference was considered to be a mean or median change in IPSS score from baseline of 3 units or more. At a significance level of 0.05 and a power of 90%, a minimum of 117 patients were needed to be recruited in the PAE arm of the study. The other primary outcome was to identify complications arising from PAE up to 12 months after the procedure. A combination of multiple imputation and propensity-matched pairing was used for a comparative between group analysis of PAE and TURP. Propensity matching was based on a logistic regression model, and yielded 65 matched pairs. The background variables used for matching were: age at procedure, length of time with LUTS, baseline IPSS, IPSS QoL, IIEF, Q_{max} and residual volume. A non-inferiority test was used to compare PAE with TURP, with an a priori margin of 3 IPSS points. For QoL, a non inferiority margin of 1 IPSS QoL point was used.

Study population issues: There were statistically significant differences in baseline characteristics of patients in the PAE group compared with the TURP group, with regard to age (mean 66 years versus 70 years, p<0.001), prostate volume (mean 101.2 ml versus 65.6 ml, p<0.001), duration of symptoms (mean 67.4 months versus 31.6 months, p<0.001) and residual void volume (mean 161.6 ml versus 263.6 ml, p=0.004).

Key efficacy and safety findings

Efficacy

No efficacy data were extracted from the unpublished registry report. A paper has been submitted for publication and efficacy data will be included when the paper has been accepted by a peer-reviewed journal.

Safety

Reported immediate clinical complications (% of total cases)

	PAE (n=216)	TURP (n=89)	HoLEP (n=13)
Sepsis	1 (0.5%)	2 (2.2%)	0 (0%)
Local arterial dissection	4 (1.9%)	0 (0%)	0 (0%)
Blood transfusion	1 (0.5%)	0 (0%)	0 (0%)
Haematoma	4 (1.9%)	0 (0%)	0 (0%)
Non-target embolisation*	2 (0.9%)	0 (0%)	0 (0%)

* These were small penile ulcers which had a self-limiting course and resolved in both patients by 6 weeks.

Patient-reported complications – 1 month follow-up

	PAE (n=143)	TURP (n=36)	HoLEP (n=5)
Haematuria	22 (15.4%)	30 (83.3%)	5 (100%)
Haematospermia	15 (10.5%)	1 (2.8%)	0 (0%)
Incontinence	1 (0.7%)	0 (0%)	0 (0%)
Urinary infection	5 (3.5%)	1 (2.8%)	0 (0%)
Retrograde ejaculation	24 (16.8 %)	10 (27.8%)	0 (0%)

Patient-reported complications – at any time after the procedure

	PAE (n=199)	TURP (n=61)	HoLEP (n=10)
Haematuria	37 (18.6%)	39 (63.9%)	8 (80.0%)
Haematospermia	25 (12.6%)	1 (1.6%)	0 (0%)
Incontinence	2 (1.0%)	2 (3.3%)	0 (0%)
Urinary infection	10 (5.0%)	1 (1.6%)	2 (20.0%)
Retrograde ejaculation	48 (24.1%)	29 (47.5%)	4 (40.0%)

Abbreviations used: HoLEP, holmium laser enucleation of the prostate; PAE, prostate artery embolisation; TURP, transurethral resection of the prostate

Study 8 Laborda A (2015)

Details

Study type	**Case report**
Country	Spain
Recruitment period	Not reported
Study population and number	**n=1** Patient with lower urinary tract symptoms associated with benign prostatic hyperplasia.
Age	63 years
Patient selection criteria	Not applicable
Technique	Selective occlusion with a platinum microcoil was done to avoid non-target embolisation. Bilateral prostate artery embolisation was then done using 300 to 500 µm Embosphere Microspheres (Biosphere Medical, France). The procedure was done during a teaching session, using the 'perfected' technique in which distal embolisation is done as a second step.
Follow-up	**3 months**
Conflict of interest/source of funding	None

Key efficacy and safety findings

Case report – Radiodermitis

The patient had multiple comorbidities including non-ST segment elevation acute coronary syndrome, sleep apnoea/hypopnea syndrome in treatment with continuous positive airway pressure and morbid obesity (body mass index 44.1 kg/m^2). He presented with increased urine frequency, nycturia, urgency, incontinence and weak urine stream, refractory to medical treatment.

International Prostate Symptom score=19; prostate specific antigen=13.7 ng/ml; prostate volume=230 cm^3 (as determined by ultrasound) and 243 cm^3 as determined by CT.

During the prostate artery embolisation (PAE) procedure, selective catheterisation of the left and right inferior vesicle arteries was especially difficult because of atherosclerosis. The procedure lasted 310 minutes, with 72 minutes of total fluoroscopy time. Measurements of radiation exposure showed a Kerma-area-product of 8,023,949 mGy cm^3 and an air kerma of 9.8 Gy.

Within 12 days of follow-up, the patient developed an erythematous lesion in the lower back and sacral area, associated with skin oedema and pigmentation, characterising radiodermitis (grade 2). This was treated with a urea-based lotion for 15 days. After 60 days, there was just a small area of skin atrophy.

The patient's lower urinary tract symptoms were successfully resolved after PAE and there was no recurrence at 3 month follow-up.

Abbreviations used: PAE, prostate artery embolisation.

Study 9 Wang M (2015)

Details

Study type	**Case report**
Country	China
Recruitment period	Not reported
Study population and number	**n=1** Patient with acute urinary retention secondary to benign prostatic hyperplasia.
Age	69 years
Patient selection criteria	Not applicable
Technique	Bilateral prostate artery embolisation (PAE) was done using 90 to 180 µm polyvinyl alcohol particles (Cook Inc., US).
Follow-up	**6 months**
Conflict of interest/source of funding	None

Key efficacy and safety findings

Case report – seminal vesicle ischaemia

The patient had a coronary stent placement 4 years before the PAE procedure, and was on maintenance clopidogrel bisulphate. He had been on medical treatment for urinary symptoms for 6 years. At baseline, the serum prostate-specific antigen (PSA) level was 5.9 ng/ml and MRI showed a large prostate of 118 ml. A prostate biopsy was negative for malignancy.

During the first 4 days after PAE, the patient had mild suprapubic pain, flatulence, and mild macroscopic haematuria without fever. These symptoms resolved spontaneously during the first week. The patient was discharged after 5 days. He urinated spontaneously with urethral catheter removal at day 11 after PAE. MRI was done at 1 week after PAE to investigate the cause of the haematuria. This showed significant infarction of the prostate and hypoperfusion in the seminal vesicle, suggestive of ischaemia. At 3 week follow-up, the patient reported a few episodes of haematospermia, which was considered to be a consequence of seminal vesicle ischaemia.

At 1 month follow-up, the haematospermia had disappeared and the patient reported significant improvement in his lower urinary tract symptoms. At 6 month follow-up, the IPSS was 6, quality of life score was 0, PSA was 3.7 ng/ml, peak urinary flow rate was 13 ml/sec, and post-void residual volume was 0. MRI showed a prostate volume of 58 ml (with 50.9% reduction). The haematospermia did not recur.

Abbreviations used: IPSS, International Prostate Symptom Score; PAE, prostate artery embolisation; PSA, prostate-specific antigen

Study 10 Costa NV (2016)

Details

Study type	**Case report**
Country	Portugal
Recruitment period	Not reported
Study population and number	**n=1** Patient with benign prostatic hyperplasia and moderate lower urinary tract symptoms.
Age	69 years
Patient selection criteria	Not applicable
Technique	Bilateral prostate artery embolisation (PAE) was done using 250 µm Embozene microspheres (CeleNova BioSciences, US).
Follow-up	**1 month**
Conflict of interest/source of funding	None

Key efficacy and safety findings

Case report – prostatic tissue expulsion

At baseline, the patient had an IPSS of 9 and a quality of life score of 4, and his symptoms were refractory to 12 months of medical therapy. Prostate size was estimated at 70 ml on transrectal sonography; PSA level was 1.93 ng/ml, peak urinary flow rate was 10.1 ml/sec and post-void residual urine volume was 212 ml.

Two weeks after PAE, the patient had increasing nocturia and urinary frequency without dysuria. At the end of the 4th week, he expelled a small tissue fragment through the urethra. Pathological analysis confirmed the microscopic aspects of prostatic tissue with extensive necrosis. The patient no longer had a weak stream, intermittency or nocturia.

At 1 month follow-up, there was a 33% reduction in prostate size, an IPSS of 3, peak urinary flow rate of 13 ml/sec, and post-void residual urine volume of 129 ml.

Abbreviations used: IPSS, International Prostate Symptom Score; PAE, prostate artery embolisation; PSA, prostate-specific antigen

Validity and generalisability of the studies

- The studies used different embolic agents, with different properties and different particle sizes. This may affect the safety and efficacy of the procedure.
- There is a large UK-based register (ROPE), which was set up in response to the 2013 NICE interventional procedure guidance 453, part-funded by NICE. The safety data from this register has been presented. The efficacy data is currently under peer-review and will be made available once accepted for publication.
- The original technique for prostate artery embolisation has been modified and 2 studies report outcomes from a newer 'PErFecTED' technique.
- Most patients had moderate to severe symptoms, according to the International Prostate Symptom Scale.
- There is likely to be some variation in the recording and rating of the severity of adverse events.
- Outcome data for follow-up periods beyond 2 years is limited.

Existing assessments of this procedure

A Health Technology Assessment on 'Prostate artery embolisation for benign prostatic hyperplasia' was published by the Ludwig Boltzmann Institute in 2017[10]. The report concluded that 'The current evidence is not sufficient to prove that PAE [in adult patients with moderate to severe LUTS] is as effective, but more safe than the comparator(s) TURP and open prostatectomy. New study results will potentially influence the effect estimate considerably. The re-evaluation is recommended in 2021.'

Related NICE guidance

Below is a list of NICE guidance related to this procedure.

Interventional procedures

- Prostate artery embolisation for benign prostatic hyperplasia. NICE interventional procedure guidance 453 (2013). This stated that the current evidence on the safety and efficacy of prostate artery embolisation for benign prostatic hyperplasia was inadequate, and that it should be used in the context of research in the form of randomised trials or cohort studies, such as an appropriate register. This guidance is currently under review and is expected to be updated in 2018. For more information, see http://www.nice.org.uk/guidance/IPG453
- Insertion of prostatic urethral lift implants to treat lower urinary tract symptoms secondary to benign prostatic hyperplasia. NICE interventional procedure guidance 475 (2014). Available from http://www.nice.org.uk/guidance/IPG475
- Uterine artery embolisation for treating adenomyosis. NICE interventional procedure guidance 473 (2013). Available from http://www.nice.org.uk/guidance/IPG473
- Uterine artery embolisation for fibroids. NICE interventional procedure guidance 367 (2010). Available from http://www.nice.org.uk/guidance/IPG367
- Holmium laser prostatectomy. NICE interventional procedure guidance 17 (2003). Available from http://www.nice.org.uk/guidance/IPG17

NICE guidelines

- Lower urinary tract symptoms in men: management. NICE clinical guideline 97 (2010; last updated: June 2015). Available from http://www.nice.org.uk/guidance/CG97

Additional information considered by IPAC

Specialist advisers' opinions

Specialist advice was sought from consultants who have been nominated or ratified by their Specialist Society or Royal College. The advice received is their individual opinion and is not intended to represent the view of the society. The advice provided by Specialist Advisers, in the form of the completed questionnaires, is normally published in full on the NICE website during public consultation, except in circumstances but not limited to, where comments are

considered voluminous, or publication would be unlawful or inappropriate.
Two Specialist Advisor Questionnaires for prostate artery embolisation for benign prostatic hyperplasia were submitted and can be found on the NICE website.

Patient commentators' opinions

NICE's Public Involvement Programme will send questionnaires to NHS trusts for distribution to patients who had the procedure (or their carers). When NICE has received the completed questionnaires, these will be discussed by the committee.

Company engagement

No structured information requests were sent to companies who manufacture a potentially relevant device for use in this procedure.

Issues for consideration by IPAC

Ongoing comparative trials or registries:

- 'Prospective, Controlled Investigation of Prostate Artery Embolization With Embosphere Microspheres Compared to Transurethral Resection of the Prostate for the Treatment of Symptomatic Benign Prostatic Hyperplasia' (NCT01789840); non-randomised, parallel assignment; US; estimated enrolment=186; study start date: July 2013; estimated study completion date: May 2018.
- 'Prospective Controlled Randomized Study of Prostatic Arteries Embolization (PAE) vs Transurethral Resection of the Prostate (TURP) for Benign Prostatic Hyperplasia (BPH) Treatment' (NCT02566551); randomised controlled trial; Spain; estimated enrolment=100; study start date: October 2015; estimated study completion date: May 2019.
- 'The Effect of Prostatic Urethral Lift (PUL) Versus Prostate Arterial Embolization (PAE), Two Novel Minimally Invasive Treatment Options on Health-related Quality of Life (HRQoL) in Men With Lower Urinary Tract Symptoms (LUTS) Secondary to Benign Prostate Hyperplasia (BPH): A Prospective, Single Center, Comparative Trial' (NCT03043222); non-

randomised, parallel assignment; US; estimated enrolment=100; study start date: November 2017; estimated study completion date: June 2019.

- 'Prostatic Artery Embolization Versus Medical Treatment in Symptomatic Benign Prostatic Hyperplasia' (NCT02869971); randomised controlled trial; France; estimated enrolment=90; study start date: August 2016; estimated study completion date: February 2021.
- 'Prostatic Artery Embolization vs. Conventional Transurethral Prostatectomy in the Treatment of Benign Prostatic Hyperplasia: A Prospective Randomized Trial' (NCT02054013); randomised controlled trial; Switzerland; enrolment=101; study start date: February 2014; estimated study completion date: December 2022.
- 'ROPE Registry Project to Determine the Safety and Efficacy of Prostate Artery Embolisation (PAE) for Lower Urinary Tract Symptoms Secondary to Benign Prostatic Enlargement (LUTS BPE)' (NCT02849522); registry; UK; enrolment=300; study start date: April 2014; estimated study completion date: September 2017.
- 'Randomized, Evaluator-blind, Controlled Trial to Evaluate the Efficacy and Safety of Prostatic Arterial Embolization Versus a Sham Procedure for Benign Prostatic Hyperplasia With Severe LUTS Not Adequately Controlled With Alpha-blockers' (NCT02074644); randomised controlled trial; Portugal; estimated enrolment=80; study start date: September 2014; estimated study completion date: December 2018.

References

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2. Gao YA, Huang Y, Zhang R et al. (2014) Benign prostatic hyperplasia: prostatic arterial embolization versus transurethral resection of the prostate--a prospective, randomized, and controlled clinical trial. Radiology 270: 920–8
3. Carnevale FC, Iscaife A, Yoshinaga EM et al. (2016) Transurethral Resection of the Prostate (TURP) Versus Original and PErFecTED Prostate Artery Embolization (PAE) Due to Benign Prostatic Hyperplasia (BPH): Preliminary Results of a Single Center, Prospective, Urodynamic-Controlled Analysis. Cardiovascular & Interventional Radiology 39: 44–52
4. Russo GI, Kurbatov D, Sansalone S et al. (2015) Prostatic Arterial Embolization vs Open Prostatectomy: A 1-Year Matched-pair Analysis of Functional Outcomes and Morbidities. Urology 86: 343–8
5. Pisco JM, Bilhim T, Pinheiro LC et al. (2016) Medium- and Long-Term Outcome of Prostate Artery Embolization for Patients with Benign Prostatic Hyperplasia: Results in 630 Patients. Journal of Vascular & Interventional Radiology 27: 1115–22
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7. Ray A, Evans J, Longford NT et al. (2017) UK Register of Prostate Embolisation (UK-ROPE) Study Evaluation report. Cedar Healthcare Technology Research Centre.
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9. Wang M, Zhang G, Yuan K et al. (2015) Seminal Vesicle Ischemia: An Unusual Complication Occurring after Prostatic Artery Embolization for the Treatment of Benign Prostatic Hyperplasia. Journal of Vascular & Interventional Radiology 26: 1580–2
10. Costa NV, Pereira J, Fernandes L et al. (2016) Prostatic Tissue Expulsion after Prostatic Artery Embolization. Journal of Vascular & Interventional Radiology 27: 601–3
11. Vreugdenburg TD, Wild C. Prostate artery embolisation for benign prostatic hyperplasia. Decision Support Document No. 105; 2017. Vienna: Ludwig Boltzmann Institute for Health Technology Assessment

Additional relevant papers

The following table outlines the studies that are considered potentially relevant to the IP overview but were not included in the main data extraction table (table 2). It is by no means an exhaustive list of potentially relevant studies. Case series with fewer than 10 patients were excluded.

Article	Number of patients/ follow-up	Direction of conclusions	Reasons for non-inclusion in table 2
Amouyal G, Thiounn N, Pellerin O et al. (2016) Clinical Results After Prostatic Artery Embolization Using the PErFecTED Technique: A Single-Center Study. Cardiovascular & Interventional Radiology 39: 367-75	Case series n=32 FU=mean 8 months	PAE using the PErFecTED technique is a safe and efficient technique to treat bothersome LUTS related to BPH. It is of interest to note that the PErFecTED technique cannot be performed in some cases for anatomical reasons.	Small case series.
Amouyal G, Chague P, Pellerin O et al. (2016) Safety and Efficacy of Occlusion of Large Extra-Prostatic Anastomoses During Prostatic Artery Embolization for Symptomatic BPH. Cardiovascular & Interventional Radiology 39: 1245-55	Case series n=11	There was a 100% rate of occlusion of the anastomosis. Bilateral embolisation of the PA was done in all patients with no additional time of procedure (p=0.18), but a significant increase of dose area product (p=0.03).	Small case series, focusing on occlusion of large extra-prostatic anastomoses.
Antunes AA, Carnevale FC, da Motta Leal Filho JM et al. (2013) Clinical, laboratorial, and urodynamic findings of prostatic artery embolization for the treatment of urinary retention related to benign prostatic hyperplasia. A prospective single-center pilot study. Cardiovascular & Interventional Radiology 36: 978-86	Case series n=11 FU=mean 22 months	Clinical and urodynamic parameters improved significantly after PAE in patients with acute urinary retention due to BPH. Total PSA at day 1 after PAE was higher in patients with unobstructed values in pressure flow studies.	Small case series.
Bagla S, Smirniotopoulos JB, Orlando JC et al. (2015) Comparative Analysis of Prostate Volume as a Predictor of Outcome in Prostate Artery Embolization. Journal of Vascular & Interventional Radiology 26: 1832–8	Case series n=78 FU=6 months	PAE offers similar clinical benefits to patients with differing gland sizes and may offer a reasonable alternative for poor candidates for urologic surgery.	A larger case series is included.
Bagla S, Martin CP, van Breda A et al. (2014) Early results from a United States trial of prostatic artery embolization in the treatment of benign prostatic hyperplasia. Journal of Vascular & Interventional Radiology 25: 47-52	Case series n=20 FU=6 months	Early results from this clinical trial indicate that PAE offers a safe and efficacious treatment option for men with BPH.	Small case series.
Bagla S, Smirniotopoulos J, Orlando JC et al. (2017) Robotic-Assisted Versus Manual Prostatic Arterial Embolization for Benign	Case series n=40 FU=3 months	Robotic-assisted PAE offers technical success comparable to manual PAE, with similar clinical	Small case series.

Prostatic Hyperplasia: A Comparative Analysis. Cardiovascular & Interventional Radiology 40: 360-365		improvement with an increased cost.	
Bagla S, Rholl KS, Sterling KM et al. (2013) Utility of cone-beam CT imaging in prostatic artery embolization. Journal of Vascular & Interventional Radiology 24: 1603-7	Case series n=15	Cone-beam CT is a useful technique that can potentially mitigate the risk of nontarget embolisation. During treatment, it can allow for the interventionalist to identify duplicated prostatic arterial supply or contralateral perfusion, which may be useful when evaluating a treatment failure.	Small case series.
Bhatia S, Harward SH, Sinha VK et al. (2017) Prostate Artery Embolization via Transradial or Transulnar versus Transfemoral Arterial Access: Technical Results. Journal of Vascular & Interventional Radiology 28: 898-905	Case series n=96	Transradial or transulnar access represents a safe and feasible approach to PAE with a comparable safety profile to transfemoral access. Reduced procedure and fluoroscopy times might be attributable to the learning curve or method of arterial access.	Small case series, focusing on different access approaches.
Bilhim T, Pisco J, Pereira JA et al. (2016) Predictors of Clinical Outcome after Prostate Artery Embolization with Spherical and Nonspherical Polyvinyl Alcohol Particles in Patients with Benign Prostatic Hyperplasia. Radiology 281: 289-300	Case series n=486 FU=median 24 months	Clinical outcome was similar after PAE with spherical polyvinyl alcohol particles (PVA) and nonspherical PVA. Younger age (up to 65 years), bilateral PAE, lower baseline IPSS, and acute urinary retention were predictors of better clinical outcome. The PSA level 24 hours after PAE correlated with prostate ischemia, and both correlated with clinical outcome.	Patient overlap with Pisco et al, 2016 (study 5).
Bilhim T, Pisco J, Campos Pinheiro L et al. (2013) Does polyvinyl alcohol particle size change the outcome of prostatic arterial embolization for benign prostatic hyperplasia? Results from a single-center randomized prospective study. Journal of Vascular & Interventional Radiology 24: 1595-602	RCT (comparing different size particles) n=80 FU=6 months	No significant differences were found in pain scores and adverse events between groups. Whereas PSA level and PV showed greater reductions after PAE with 100-micro m PVA particles, clinical outcome was better with 200-micro m particles.	RCT comparing different particle sizes for embolisation. Article is included in Shim SR et al, 2017 (study 1).
Bilhim T, Pisco J, Rio Tinto H et al. (2013) Unilateral versus bilateral prostatic arterial embolization for lower urinary tract symptoms in patients with prostate enlargement. Cardiovascular & Interventional Radiology 36: 403-11	Case series n=122 FU=mean 7 months	PAE is a safe and effective technique that can induce 48% improvement in the IPSS score and a prostate volume reduction of 19%, with good clinical outcome in up to 75% of treated patients. Bilateral PAE seems to lead to better clinical results; however, up to 50% of patients after unilateral PAE	Larger studies are included. Article is included in Shim SR et al, 2017 (study 1).

		may have a good clinical outcome.	
Carnevale FC, da Motta-Leal-Filho JM, Antunes AA et al. (2013) Quality of life and clinical symptom improvement support prostatic artery embolization for patients with acute urinary retention caused by benign prostatic hyperplasia. Journal of Vascular & Interventional Radiology 24: 535–42	Case series n=11 FU=mean 29 months	Patients with severe symptoms and acute urinary retention caused by BPH can be treated safely by PAE, which improves clinical symptoms and QoL.	Small case series.
Cizman Z, Isaacson A, Burke C (2016) Short- to Midterm Safety and Efficacy of Prostatic Artery Embolization: A Systematic Review. Journal of Vascular & Interventional Radiology 27: 1487-1493	Systematic review 7 studies (n=562)	PAE improves lower urinary tract symptoms caused by BPH, with a favourable short- to midterm safety profile.	A more recent systematic review is included.
de Assis AM, Moreira AM, de Paula Rodrigues VC et al. (2015) Prostatic artery embolization for treatment of benign prostatic hyperplasia in patients with prostates > 90 g: a prospective single-center study. Journal of Vascular & Interventional Radiology 26: 87-93	Case series n=35 FU=3 months	PAE is a safe and effective treatment for lower urinary tract symptoms secondary to benign prostatic hyperplasia in patients with prostate volume >90 g. Excessively elevated prostate-specific antigen within 24 hours of PAE is associated with lower symptom burden in short-term follow-up.	Small case series.
de Assis AM, Maciel MS, Moreira AM et al. (2017) Prostate Zonal Volumetry as a Predictor of Clinical Outcomes for Prostate Artery Embolization. Cardiovascular & Interventional Radiology 40: 245-251	Case series n=93 FU=6 months	Baseline central gland and whole prostate volumes as well as prostate zonal volumetry index (ZVi) presented strong correlation with clinical outcomes in patients undergoing PAE, and its assessment should be considered in pre-treatment evaluation whenever possible. Both patients and medical team should be aware of the possibility of less favorable outcomes when ZVi<0.45.	Larger studies are included.
Feng S, Tian Y, Liu W et al. (2017) Prostatic Arterial Embolization Treating Moderate-to-Severe Lower Urinary Tract Symptoms Related to Benign Prostate Hyperplasia: A Meta-Analysis. Cardiovascular & Interventional Radiology 40: 22-32	Systematic review and meta-analysis 20 studies (1318 patients)	PAE should be considered to be the very promising alternative treatment for those who do not want or cannot tolerate surgical treatment, with its benefits on IPSS, QoL score, PSA level, prostate volume, Q_{max}, and post-void residual without affecting erectile function.	Another systematic review, which presents results for comparative studies and non-comparative studies, is included.
Frenk NE, Baroni RH, Carnevale FC et al. (2014) MRI findings after prostatic artery embolization for treatment of benign hyperplasia.	Case series n=17	MRI can be used for assessing the development of infarcts and volume reduction in the prostate after	Small case series. Focusing on the use of MRI.

AJR. American Journal of Roentgenology 203: 813-21		embolisation. Further studies are needed to correlate these findings to clinical outcome.	
Gabr AH, Gabr MF, Elmohamady BN et al. (2016) Prostatic Artery Embolization: A Promising Technique in the Treatment of High-Risk Patients with Benign Prostatic Hyperplasia. Urologia Internationalis 97: 320-324	Case series n=22 FU=9 months	The PAE procedure was successful in all patients. Throughout the period of follow-up, there was a significant improvement in the LUTS and urinary flow rate, and reduction in prostate volume and serum PSA (for all $p<0.001$). No major complications were reported.	Small case series.
Goncalves OM, Carnevale FC, Moreira AM et al. (2016) Comparative Study Using 100-300 Versus 300-500 mum Microspheres for Symptomatic Patients Due to Enlarged-BPH Prostates. Cardiovascular & Interventional Radiology 39: 1372-8	Non-randomised comparative study (comparing different particle sizes) n=30 FU=3 months	Both 100-300 and 300-500 mum microspheres are safe and effective embolic agents for PAE to treat LUTS-related to BPH. Although functional and imaging outcomes did not differ significantly following use of the two embolic sizes, the greater incidence of adverse events with 100-300 mum microspheres suggests that 300-500 mum embolic materials may be more appropriate.	Small study, focusing on different particle sizes for embolisation.
Grosso M, Balderi A, Arno M et al. (2015) Prostatic artery embolization in benign prostatic hyperplasia: preliminary results in 13 patients. Radiologia Medica 120: 361-8	Case series n=13 FU= mean 244 days	PAE may play an important role in patients in whom medical therapy has failed, who are not candidates for surgery or transurethral prostatic resection (TURP) or refuse any surgical treatment.	Small case series.
Isaacson AJ, Fischman AM, Burke CT (2016) Technical Feasibility of Prostatic Artery Embolization From a Transradial Approach. AJR. American Journal of Roentgenology 206: 442-4	Case series n=19	Technical success was achieved in all 19 procedures. The associated complications were minor and included 2 small (<5 cm) hematomas and 1 potential case of delayed radial arteritis. PAE performed with a transradial approach is technically feasible.	Small case series.
Isaacson AJ, Raynor MC, Yu H et al. (2016) Prostatic Artery Embolization Using Embosphere Microspheres for Prostates Measuring 80-150 cm^3: Early Results from a US Trial. Journal of Vascular & Interventional Radiology 27: 709-14	Case series n=12 FU=3 months	Mean improvements in International Prostate Symptom Score and quality of life score were 18.3 points (range 5 to 27) and 3.6 points (range 1 to 6), respectively. One-month cystoscopies and anoscopies demonstrated no ischemic injuries. There were no major complications.	Small case series.
Jones P, Rai BP, Aboumarzouk OM et al. (2016) Prostatic Urethral Lift Vs Prostate Arterial Embolization: Novel Nonablative Strategies in the Management of	review	Prostate urethral lift and PAE represent 2 evolving techniques with contrasting mechanisms of action. Both yield relief of lower urinary	A more recent systematic review is included.

Lower Urinary Tract Symptoms Secondary to Benign Prostate Hyperplasia. Urology 87: 11-7		tract symptoms over a period of several weeks. They display similar safety profiles with self-limiting pelvic discomfort characterizing the commonest minor adverse event. Both procedures have the potential to be carried out under local anaesthesia and in the outpatient setting with suitability for patients with cardiovascular comorbidities. Neither has been found to cause degradation of sexual function. Further randomised studies are needed to delineate the formal position of these techniques in the surgical management of benign prostate hyperplasia.	
Kisilevzky N, Laudanna Neto C, Cividanes A (2016) Ischemia of the Glans Penis following Prostatic Artery Embolization. Journal of Vascular & Interventional Radiology 27: 1745-1747	Case report n=1	On day 11 after PAE, the patient had a necrotic area on the glans penis. The wound healed after 40 days, with conservative treatment.	Adverse event is already described in table 2.
Kisilevzky N, Faintuch S (2016) MRI assessment of prostatic ischaemia: best predictor of clinical success after prostatic artery embolisation for benign prostatic hyperplasia. Clinical Radiology 71: 876-82	Case series n=24 FU=17 months	Clinical success was achieved in 15 patients (63%) with prostate volume decreasing 24% versus 16% (p=0.03) in the unsuccessful cases. Thirteen of the 15 successful cases (87%) showed ischaemic areas in the prostate on MRI obtained 30 days after embolisation, but only 1 unsuccessful case (11%) showed a very small area of ischaemia.	Small case series.
Kuang M, Vu A, Athreya SA (2017) Systematic Review of Prostatic Artery Embolization in the Treatment of Symptomatic Benign Prostatic Hyperplasia. Cardiovascular & Interventional Radiology 40: 655-663	Systematic review 10 studies (788 patients)	PAE is effective in treating lower urinary tract symptoms in the short and intermediate term.	A systematic review with a more recent search date is included.
Kurbatov D, Russo GI, Lepetukhin A et al. (2014) Prostatic artery embolization for prostate volume greater than 80 cm^3: results from a single-center prospective study. Urology 84: 400–4	Case series n=88 FU=1 year	We showed clinical benefits of PAE for the treatment of lower urinary tract symptoms or BPO by reducing IPSS, prostate volume, PSA, postvoid residue, and improvement in urinary flow and QoL after 1 year in patients with prostate volume ≥80 cm^3 and Charlson comorbidity index ≥2.	A larger case series is included. Article is included in Shim SR et al, 2017 (study 1).
Lebdai S, Delongchamps NB, Sapoval M et al. (2016) Early	Systematic review	Early reports suggest that PAE may be a promising	A systematic review with a

results and complications of prostatic arterial embolization for benign prostatic hyperplasia. World Journal of Urology 34: 625-32	4 studies	procedure for the treatment of patients with LUTS due to BPO. However, the low level of evidence and short follow-up of published reports preclude any firm conclusion on its mid-term efficiency. Further clinical trials are warranted before any use in clinical practice.	more recent search date is included.
Leite LC, de Assis AM, Moreira AM et al. (2017) Prostatic Tissue Elimination After Prostatic Artery Embolization (PAE): A Report of Three Cases. Cardiovascular & Interventional Radiology 40: 937-941	Case reports n=3	Urethral obstruction after PAE caused by sloughing prostate tissue is a potential complication of the procedure and should be considered in patients with recurrent LUTS in order to avoid inappropriate management.	Adverse event is already described in table 2.
Li Q, Duan F, Wang MQ et al. (2015) 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 128: 2072-7	Case series n=24 FU=12 months	The combination of 50 mum and 100 mum particles for PAE is a safe and effective treatment method for patients with severe LUTS due to large BPH, which further improves the clinical results of PAE.	Small case series.
Little MW, Boardman P, Macdonald AC et al. (2017) Adenomatous-Dominant Benign Prostatic Hyperplasia (AdBPH) as a Predictor for Clinical Success Following Prostate Artery Embolization: An Age-Matched Case-Control Study. Cardiovascular & Interventional Radiology 40: 682-689	Case series n=24	This is the first time that Adenomatous-Dominant Benign Prostatic Hyperplasia has been identified as being a predictor of clinical success following PAE.	Small case series.
Maclean D, Maher B, Modi S et al. (2017) Prostate artery embolization: A new, minimally invasive treatment for lower urinary tract symptoms secondary to prostate enlargement. Therapeutic Advances in Urology 9: 209-216	Review	The ionising radiation dose area product per procedure is around 17,400 μGy/m^2 or an effective dose of approximately 47 mSv. This is roughly equivalent to an additional lifetime cancer risk of 0.2% (baseline risk for men is 44.9%) in a patient population with an average age of 65. Initial evidence suggests PAE has a role to play in the management of BPH, but its role is still evolving.	A systematic review is included.
Mirakhur A, McWilliams JP (2017) Prostate Artery Embolization for Benign Prostatic Hyperplasia: Current Status. Canadian Association of Radiologists Journal 68: 84-89	Review n=11 studies (741 patients)	Current evidence suggests it is a safe and effective option for patients with medication-refractory urinary obstructive symptoms who are poor surgical candidates or refuse surgical therapy. Larger, randomised studies with long-	A systematic review with a more recent search date is included.

		term follow-up data are needed for this technique to be formally established in the treatment paradigm for benign prostatic hyperplasia.	
Moreira AM, de Assis AM, Carnevale FC et al. (2017) A Review of Adverse Events Related to Prostatic Artery Embolization for Treatment of Bladder Outlet Obstruction Due to BPH. Cardiovascular Interventional Radiology DOI 10.1007/s00270-017-1765-3	Review	The prostate gland is the most common source of complaints following PAE, where the inflammatory process can create a large variety of localised symptoms. Periprostatic organs and structures such as bladder, rectum, penis, seminal vesicle, pelvis, bones and skin may be damaged by nontarget embolization, especially due to the misidentification of the normal vascular anatomy and variants or due to inadvertent embolic reflux. Radiodermatitis may also happen in case of small vessel size, atherosclerosis, the learning curve and long procedure or fluoroscopy times.	Review is largely descriptive.
Moreira AM, Marques CF, Antunes AA et al. (2013) Transient ischemic rectitis as a potential complication after prostatic artery embolization: case report and review of the literature. Cardiovascular & Interventional Radiology 36: 1690-4	Case report n=1	During the first 3 days of follow-up, a small amount of blood mixed in the stool was observed. Colonoscopy identified rectal ulcers at day 4, which had then disappeared by day 16 post PAE without treatment. PAE is a safe, effective procedure with a low complication rate, but interventionalists should be aware of the risk of rectal nontarget embolisation.	Nontarget embolisation is already described as an adverse event in table 2.
Pisco J, Bilhim T, Pinheiro LC et al. (2016) Prostate Embolization as an Alternative to Open Surgery in Patients with Large Prostate and Moderate to Severe Lower Urinary Tract Symptoms. Journal of Vascular & Interventional Radiology 27: 700–8	Case series n=152 FU=median 18 months	There were 33 clinical failures (24%); 23 occurred in the short-term (≤6 months), and 10 occurred in the medium-term (6-24 months); there were no long-term failures (>36 months). Cumulative clinical success rates were 90%, 88%, 84%, 81%, and 78% at 1, 3, 6, 12, and 18 months and 72% thereafter to 66 months.	A larger case series is included.
Pisco JM, Rio Tinto H, Campos Pinheiro L et al. (2013) Embolisation of prostatic arteries as treatment of moderate to severe lower urinary symptoms (LUTS) secondary to benign hyperplasia: results of short- and	Case series n=255 FU=mean 10 months	PAE is a procedure with good results for BPH patients with moderate to severe LUTS after failure of medical therapy.	A larger case series from the same centre is included. Article is included in Shim SR et al, 2017 (study 1).

mid-term follow-up. European Radiology 23: 2561-72			
Pisco J, Campos Pinheiro L, Bilhim T et al. (2013) Prostatic arterial embolization for benign prostatic hyperplasia: short- and intermediate-term results. Radiology 266: 668–77	Case series n=89 FU=mean 8 months	PAE is a safe and effective procedure, with low morbidity, no sexual dysfunction, and good short- and intermediate-term symptomatic control associated with prostate volume reduction.	More recent studies are included. Article is included in Shim SR et al, 2017 (study 1).
Pisco JM, Pinheiro LC, Bilhim T et al. (2011) Prostatic arterial embolization to treat benign prostatic hyperplasia. Journal of Vascular and Interventional Radiology 22: 11–9	Case series n=15 FU=mean 8 months	Technical success: 93% (14/15) patients. One 'major complication' (1.5 cm^2 ischaemic area of the bladder wall treated by surgical removal of ischaemic area) in 1 patient.	Small case series. Included in table 2 of overview used for guidance published in 2013.
Pyo JS, Cho WJ (2017) Systematic review and meta-analysis of prostatic artery embolisation for lower urinary tract symptoms related to benign prostatic hyperplasia. Clinical Radiology 72: 16–22	Systematic review 7 studies (n=484)	The present data shows that PAE could improve lower urinary tract symptoms by BPH after short- and mid-term follow-up; however, more cumulative studies for long-term follow-up and comparison with other therapeutic modalities will be needed.	A more recent systematic review is included.
Rampoldi A, Barbosa F, Secco S et al. (2017) Prostatic Artery Embolization as an Alternative to Indwelling Bladder Catheterization to Manage Benign Prostatic Hyperplasia in Poor Surgical Candidates. Cardiovascular & Interventional Radiology 40: 530-6	Case series n=43 Fu=mean 13 months	PAE is a safe and feasible for the relief of lower urinary tract symptoms and indwelling bladder catheterisation in highly comorbid patients without surgical treatment options.	A larger case series is included.
Rio Tinto H, Martins Pisco J, Bilhim T et al. (2012) Prostatic artery embolization in the treatment of benign prostatic hyperplasia: short and medium follow-up. Techniques in Vascular & Interventional Radiology 15: 290–3	Case series n=103 FU=up to 2 years	6 months after the procedure, the prostate volume decreased about 23%, IPSS changed to a mean value of 11.95 (almost 50% reduction), the QoL improved slightly more than 2 points, the Q(max) changed to a mean value of 12.63 ml/sec, the postvoid residual was almost half of the baseline value, and the PSA decreased about 2.3 ng/mL. In the mid-term follow-up, there was still a reduction in PV, IPSS, QoL, PVR, and PSA, and an increase in Q(max).	More recent studies are included. Patient overlap with Pisco J et al, 2013.
Schreuder SM, Scholtens AE, Reekers JA et al. (2014) The role of prostatic arterial embolization in patients with benign prostatic hyperplasia: a systematic review. Cardiovascular & Interventional Radiology 37: 1198-219	Systematic review 9 studies (706 patients)	Although the number of studies was small, qualitatively poor, and with overlap of patients, the initial clinical outcomes as reported up to 12 months seem	A systematic review with a more recent search date is included.

		positive and the procedure seems safe.	
Shaker M, Abd El Tawab KA, Abd El Tawab KH et al. (2016) Role of prostatic artery embolization in management of symptomatic benign prostatic hyperplasia. Egyptian Journal of Radiology and Nuclear Medicine 47: 839-845	Case series n=28 FU=6 months	No major complications were recorded. Clinical success=96% (27/28) of patients.	Small case series.
Teoh JY, Chiu PK, Yee CH et al. (2017) Prostatic artery embolization in treating benign prostatic hyperplasia: a systematic review. International Urology & Nephrology 49: 197-203	Systematic review 5 studies	Evidence on different aspects of PAE was limited. Further studies are warranted to investigate the role of PAE as compared to other forms of medical and surgical treatment.	A systematic review with a more recent search date is included.
Uflacker A, Haskal ZJ, Bilhim T et al. (2016) Meta-Analysis of Prostatic Artery Embolization for Benign Prostatic Hyperplasia. Journal of Vascular & Interventional Radiology 27: 11 1686-1697	Meta-analysis 19 studies (6 in meta-analysis)	PAE provided improvement in Q_{max}, postvoid residual, IPSS, and QOL endpoints at 12 months, with a low incidence of serious adverse events (0.3%), although minor adverse events were common (33%). There was no adverse effect on erectile function.	A systematic review with a more recent search date is included.
Wang XY, Zong HT, Zhang Y (2016) Efficacy and safety of prostate artery embolization on lower urinary tract symptoms related to benign prostatic hyperplasia: a systematic review and meta-analysis. Clinical Interventions In Aging 11: 1609-1622	Systematic review and met-analysis 12 studies (840 patients)	PAE is an effective, safe and well-tolerable treatment for lower urinary tract symptoms related to BPH, including large volume BPH, with a good short-term follow-up. Studies with large number of cases and longer follow-up time are needed to validate our results.	A more recent systematic review is included.
Wang MQ, Wang Y, Yan JY et al. (2016) Prostatic artery embolization for the treatment of symptomatic benign prostatic hyperplasia in men >=75 years: a prospective single-center study. World Journal of Urology 34: 1275–83	Case series n=157 FU=mean 20 months	PAE could be used as an effective, safe, and well tolerable method in the treatment of elderly symptomatic BPH patients, similarly to younger patients, and it may play an important role in patients in whom medical therapy has failed, who are at high surgical and anaesthetic risk or who refuse the standard surgical therapy.	A larger case series is included.
Wang M, Guo L, Duan F et al. (2015) Prostatic arterial embolization for the treatment of lower urinary tract symptoms as a result of large benign prostatic hyperplasia: A prospective single-center investigation. International Journal of Urology 22: 766-72	Case series n=64 FU=mean 18 months	Prostatic arterial embolization seems to be a safe and effective treatment method for patients with lower urinary tract symptoms as a result of large benign prostatic hyperplasia, and it might play an important role for patients in whom medical therapy has failed, who are not candidates for surgical treatment.	A larger case series is included. Article is included in Shim SR et al, 2017 (study 1).

Wang MQ, Guo LP, Zhang GD et al. (2015) Prostatic arterial embolization for the treatment of lower urinary tract symptoms due to large (>80 mL) benign prostatic hyperplasia: results of midterm follow-up from Chinese population. BMC Urology 15: 33 doi: 10.1186/s12894-015-0026-5.	Case series n=117 FU=mean 24 months	PAE is a safe and effective treatment method for patients with LUTS due to large volume BPH. PAE may play an important role in patients in whom medical therapy has failed, who are not candidates for open surgery or TURP or refuse any surgical treatment.	A larger case series is included. Article is included in Shim SR et al, 2017 (study 1).
Wang M, Guo L, Duan F et al (2016) Prostatic arterial embolization for the treatment of lower urinary tract symptoms caused by benign prostatic hyperplasia: a comparative study of medium- and large-volume prostates. BJU International 117: 155-64	Case series n=115 FU=mean 17 months	PAE is a safe and effective treatment method for patients with LUTS attributable to BPH. The clinical and imaging outcomes of PAE were better in patients with larger prostate glands than medium-sized ones.	A larger case series is included.
Wang MQ, Duan F, Yuan K et al. (2017) Benign Prostatic Hyperplasia: Cone-Beam CT in Conjunction with DSA for Identifying Prostatic Arterial Anatomy. Radiology 282: 271-280	Case series n=148	Cone-beam CT is a useful adjunctive technique to digital subtraction angiography for identification of the prostatic artery anatomy and provides information to help treatment planning during prostatic arterial embolisation.	Study focuses on the use of cone-beam CT imaging.
Yu SC, Cho CC, Hung EH et al. (2017) Prostate Artery Embolization for Complete Urinary Outflow Obstruction Due to Benign Prostatic Hypertrophy. Cardiovascular & Interventional Radiology 40: 33-40	Case series n=37 FU=1 month	PAE was probably safe and effective in weaning of catheter and relieving obstructive urinary symptoms in patients due to BPH, with treatment outcomes comparable to those without acute urinary retention.	Small case series.
Zhang G, Wang M, Duan F et al. (2015) Radiological Findings of Prostatic Arterial Anatomy for Prostatic Arterial Embolization: Preliminary Study in 55 Chinese Patients with Benign Prostatic Hyperplasia. PLoS ONE [Electronic Resource] 10: e0132678	Case series n=55	The prostatic vascularization is complex with frequent anatomic variations. Knowledge of the vascular anatomy of the prostate may provide indications for planning PAE and avoiding nontarget embolisation.	Small case series.

Literature search strategy

Databases	Date searched	Version/files
Cochrane Database of Systematic Reviews – CDSR (Cochrane)	15/08/2017	Issue 8 of 12, August 2017
HTA database (Cochrane)	15/08/2017	Issue 4 of 4, October 2016
Cochrane Central Register of Controlled Trials (Cochrane)	15/08/2017	Issue 7 of 12, July 2017
MEDLINE (Ovid)	15/08/2017	1946 to August Week 1 2017
MEDLINE In-Process (Ovid)	15/08/2017	August 14, 2017
EMBASE (Ovid)	15/08/2017	1974 to 2017 Week 33
PubMed	15/08/2017	n/a
BLIC (British Library)	15/08/2017	n/a

Trial sources searched

- Clinicaltrials.gov
- ISRCTN
- WHO International Clinical Trials Registry

Websites searched

- National Institute for Health and Care Excellence (NICE)
- NHS England
- Food and Drug Administration (FDA) - MAUDE database
- Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP – S)
- Australia and New Zealand Horizon Scanning Network (ANZHSN)
- EuroScan
- General internet search

The following search strategy was used to identify papers in MEDLINE. A similar strategy was used to identify papers in other databases.

1	Arteries/
2	Catheterization/
3	1 or 2
4	Embolization, Therapeutic/
5	3 and 4
6	((Arter* or catheter* or cannula*) adj4 emboli*).tw.
7	PAE.tw.
8	Surgical Procedures, Minimally Invasive/
9	(Mini* adj4 invasive* adj4 (surg* or procedure* or tech* or intervent* or treat*)).tw.

10	or/5-9
11	Prostatic Hyperplasia/
12	(Benign adj4 prostat* adj4 (hyperplasia* or enlarge* or hypertroph* or obstruct*)).tw.
13	(BPH or BPO or BPE).tw.
14	((Adenofibromatous* or Adenofibromyomatous* or adenoma* or glandular* or stromal*) adj4 (hyperplasia* or enlarge* or hypertroph* or obstruct*)).tw.
15	Lower Urinary Tract Symptoms/
16	(low* adj4 urin* adj4 tract* adj4 symptom*).tw.
17	LUTS.tw.
18	Urinary Bladder Neck Obstruction/
19	(bladder adj4 (outflow* or outlet* or neck*) adj4 obstruct*).tw.
20	BOO.tw.
21	Prostatism/
22	Prostatism*.tw.
23	or/11-22
24	10 and 23
25	Animals/ not Humans/
26	24 not 25
27	(201211* or 201212* or 2013* or 2014* or 2015* or 2016* or 2017*).ed.
28	26 and 27