Two-year Outcomes after Transurethral Prostate Resection Post-prostatic Artery Embolization Versus Transurethral Prostate Resection Alone For Giant Benign Prostatic Hyperplasia

Zhang Zhiyu[1]*, Song Zhen[1]*, Zhou Qi[2]*, Huang Yuhua[1], Ouyang Jun[1], Zhang Xuefeng[1]

Purpose: To compare the long-term (two-year) efficacy between transurethral resection of the prostate (TURP) after prostatic artery embolization (PAE) and TURP only for patients with giant (>100 mL) benign prostatic hyperplasia.

Materials and Methods: We retrospectively analyzed data from 61 and 150 patients with giant benign prostatic hyperplasia treated with PAE+TURP or TURP alone, respectively, from January 2015 to March 2020. We compared index changes before and after surgery.

Results: The operative time, intraoperative blood loss, postoperative bladder irrigation time, and catheter retention time in the PAE+TURP group were lower than those of the TURP group, while the speed of resection of the lesion and hospitalization costs were more significant ($P < 0.05$). International prostate symptom score (IPSS), quality of life (QoL), prostate volume, maximum urinary flow rate, detrusor pressure of maximum urinary flow rate, prostate-specific antigen, and urodynamic obstruction were better in the PAE+TURP group than the TURP group at 24 months ($P < 0.05$). Regarding IPSS and QoL scores at 24 months postoperatively compared with the preoperative period, the PAE+TURP group was better than the TURP group in terms of the storage period, voiding period, and QoL ($P < 0.05$). The distribution of postoperative adverse event severity classes was comparable between the groups ($P = 0.984$).

Conclusion: In contrast to TURP alone, PAE + TURP is more expensive but provides better postoperative outcomes; there is no significant difference in terms of the severity grade distribution of postoperative complications.

Keywords: giant benign prostatic hyperplasia; transurethral resection of the prostate; prostatic artery embolization; efficacy

INTRODUCTION

Benign prostatic hyperplasia (BPH) severely affects the quality of life (QoL) of middle-aged and older men, with incidence rates ranging from 50% in the sixth decade to nearly 90% in the eighth decade of life.[1] BPH presents with enhanced urination frequency, urgency, and progressive urinary difficulty, facilitating the formation of urinary stones, urinary retention, urinary tract infections, and chronic kidney disease. Conservative treatment of BPH is less effective than other treatment strategies, and surgery is thought to be the most efficacious. Although several surgical options are available, transurethral resection of the prostate (TURP) is the procedure of choice for patients who have failed pharmacological treatment with adenomas less than 80 mL.[2] Despite the efficacy of this treatment, few studies have reported differences among treatment strategies for large prostates (≥ 100 mL). Previous studies have shown that direct surgery may be associated with longer operative times and increased blood loss for these older male patients, increasing the procedure's risks.[3]

Prostatic artery embolization (PAE) improves bladder outlet obstruction due to BPH and reduces the incidence of post-TURP complications.[4-5] However, the exclusive use of PAE to treat BPH is controversial, and many clinicians recommend a combined approach with other treatments to improve lower urinary tract symptoms (LUTS). PAE plays an adjunctive role in this combination.[6] Previous work has shown that TURP combined with PAE can reduce the blood supply to the augmented area, reducing intraoperative bleeding, improving the procedure's safety, and shortening the operative time.

In the present study, we compared the long-term efficacy, safety, and complications of PAE+TURP versus TURP alone to manage giant BPH (> 100 mL) with a two-year follow-up.

PATIENTS AND METHODS

Study population

Data from 201 patients with large BPH from the First Affiliated Hospital of Soochow University was collected from January 2015 to March 2020. Of these 201 patients, 61 were treated with PAE + TURP, and 150 were treated with TURP alone. The patients were then followed up for two years. The international prostate symptom score (IPSS) and other outcomes were as-

[1]Department of Urology, the First Affiliated Hospital of Soochow University, Suzhou, China.
[2]Department of Reproductive Medicine Center, the First Affiliated Hospital of Soochow University, Suzhou, China.
*Correspondence: The First Affiliated Hospital of Soochow University, Suzhou City, Jiangsu Province, PRC. Tel: +86 13041470376. E-mail: drzhangxuefeng@126.com.
* These authors contributed equally to this work.
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Table 1. Comparison of baseline characteristics of all enrolled patients between PAE + TURP Group and TURP Group

Characteristic	PAE+TURP	TURP	*P*
n	61	150	
HBP (Yes / No), n (%)	33 (15.6 %) / 28 (13.3 %)	72 (34.1 %) / 78 (37 %)	.515
DM (Yes / No), n (%)	6 (2.8 %) / 55 (26.1 %)	22 (10.4 %) / 128 (60.7 %)	.475
Age (yr), mean ± SD	73.49 ± 8.48	72.47 ± 7.12	.183
BMI (kg/m2), mean ± SD	24.28 ± 3.24	24.33 ± 3.20	.964
PSA (ng/mL), mean ± SD	6.95 ± 3.53	7.03 ± 3.35	.813
PV (mL), mean ± SD	123.60 ± 29.29	123.50 ± 25.32	.473
PVR volume(mL), mean ± SD	166.5 ± 125.00	143.5 ± 7.97	.538
IPSS, mean ± SD	26.95 ± 4.55	26.53 ± 3.87	.377
QoL, mean ± SD	5.00 ± 0.77	4.95 ± 0.61	.702
Qmax (mL/s),mean±SD	5.63 ± 2.91	6.28 ± 2.80	.096
PdetQmax (cmH_2O), mean ± SD	87.26 ± 22.44	82.23 ± 19.67	.166
NIH-CPSI, mean ± SD	31.31 ± 5.49	31.53 ± 4.15	.591
IIEF-5, mean ± SD	10.70 ± 5.36	11.09 ± 4.48	.316

Abbreviations: PAE, prostate artery embolization; TURP, transurethral resection of the prostate; HBP, high blood pressure; DM, diabetes mellitus; BMI, body mass index; PSA, prostate specific antigen; PV, prostate volume; PVR, postvoid residual; IPSS, international prostate symptom score; QoL, quality of life; Qmax, maximum urinary flow rate; PdetQmax, detrusor pressure of maximum urinary flow rate; NIH-CPSI, national institutes of health-chronic prostatitis symptom index; IIEF, international index of erectile function; SD, standard deviation

sessed 24-months postoperatively. Additionally, differences in the follow-up indicators of two surgical approaches at each time point were noted. In the initial cohort, excluding missing data, loss to follow-up, or death, 167 patients were followed up for 24-months (52 PAE + TURP and 115 TURP).

Inclusion criteria: (1) BPH patients with moderate-to-severe LUTS and significantly impaired QoL (i.e., IPSS > 8 and QoL score > 3); (2) poor results from medication or refusal to take medication; (3) recurrent episodes of hematuria, urinary retention, or urinary tract infection; (4) secondary hydronephrosis of the upper urinary tract with or without renal impairment; (5) urodynamic examination suggesting bladder outflow tract obstruction with no abnormal bladder function; (6) a prostate volume (PV) > 100 cm^3.

Exclusion criteria: (1)Patients with imaging data suggesting severe internal iliac artery or prostatic artery sclerosis and tortuous vessels, detrusor weakness or neurogenic lower urinary tract dysfunction, comorbid urethral strictures, large bladder diverticula, bladder stones, or prostate cancer, severe cardiac, hepatic, or renal insufficiency or coagulation dysfunction; (2) allergy to iodine-containing contrast media or contraindications to magnetic resonance imaging; (3) prior history of prostate surgery, or iliac artery embolization.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethics committee of the First Affiliated Hospital of Soochow University (No. 139) and informed consent was taken from all individual participants.

Operative method

TURP

Three experienced surgeons performed the TURP technique. Under intravenous inhalation compound anesthesia, a German Wolf bipolar prostate electrospectroscope and the supporting photography system were used to observe the lesion and surrounding tissue. The power of the electrospectroscope was set at 100–120 W, and the power of electrocoagulation was 60–80 W. The F26 electrospectroscope was slowly placed to explore the patient's verumontanum, urethra, ureteral orifice, prostate, and bladder, carefully observing the prostate lesion from the verumontanum to the bladder neck orifice. Then, the bladder neck opening and the verumontanum were used as markers. Middle lobe hyperplasia requires tissue excision within the 5 to 7 o'clock range. Lateral lobe hyperplasia requires tissue excision within the 1 to 11 o'clock range (as deep as possible into the surgical envelope of the prostate). Finally, the gland surrounding the verumontanum was excised. Electrocoagulation was performed to stop the bleeding and repair the wound. An Ellik was used to aspirate the tissue fragments for pathological examination. Postoperatively, an F20 balloon catheter was left in place, and the bladder was flushed with saline until the fluid color became transparent.

PAE+TURP

Two experienced interventional surgeons performed the PAE technique. An F16 urinary catheter was placed

Table 2. Distribution and managements of adverse events after operation in PAE+TURP Group and TURP Group based on Common Terminology Criteria for Adverse Events (CTCAE).

Type of complications	PAE+TURP Group	TURP Group	Managements
Hematuria, mild	15	14	Hemostatic drug application, bladder flushing, urinary canal traction
Hematuria, severe	1	7	Blood transfusion, surgical hemostasis
Irritation, pain, discomfort	41	137	Acesodyne, antispasmodic drug
Urinary tract infection	36	80	Anti-infective drug
Urinary retention	3	13	Catheterization
Strictures (meatal)	2	4	Urethral dilatation
Strictures (bladder neck)	0	1	Transurethral resection of the bladder neck
Other adverse events	2	9	
Total	100	256	

Abbreviations: PAE, prostate artery embolization; TURP, transurethral resection of the prostate

Table 3. Comparison of intraoperative and postoperative indexes between PAE + TURP Group and TURP Group

Characteristic	PAE+TURP	TURP	*P*
n	61	150	
ASA scores, n(%)			.4303
I	17 (8.1 %)	48 (22.7 %)	
II	39 (18.5 %)	92 (43.6 %)	
III	5 (2.4 %)	10 (4.7 %)	
Operation time (min), mean ± SD	68.56 ± 14.98	128.40 ± 27.51	< .001
Resected tissue weight (g), mean ± SD	96.97 ± 26.99	96.14 ± 24.23	.859
Speed of excised lesion (g/h), mean ± SD	73.34 ± 8.14	45.33 ± 7.06	< .001
Intraoperative blood loss (mL), mean ± SD	34.02 ± 14.91	65.87 ± 43.94	< .001
Postoperative bladder flushing time (d), mean ± SD	1.66 ± 0.87	2.43 ± 1.38	< .001
Postoperative catheter retention time (d), mean ± SD	7.59 ± 2.04	9.11 ± 3.48	.011
Hositalization time (d), mean ± SD	3.93 ± 1.44	4.27 ± 1.53	.057
Cost (RMB), mean ± SD	42369.71 ± 13722.51	26214.28 ± 6910.75	< .001
Clavien Grade, n (%)			.984
≤II	59 (28.0 %)	145 (68.7 %)	
≥III	2 (0.9 %)	5 (2.4 %)	

Abbreviations: ASA, American society of Aneshesiologists; PAE, prostate artery embolization; TURP, transurethral resection of the prostate; RMB, Chinese Yuan; SD, standard deviation

before the procedure. The balloon was filled with 10 mL of contrast mixed with a 0.9% sodium chloride solution, and the urinary catheter was gently pulled back to place the balloon at the urethra internal orifice. After the successful induction of local anesthesia, the modified Seldinger technique was used to puncture the right femoral artery, and a 5-F Cobra arterial catheter (Cook, USA) was placed in the anterior trunks of both internal iliac arteries. The x-ray tube was tilted 35° to the same side, and 9–12 mL of iodixanol contrast was injected at 3–4 mL/s and a pressure of 300 psi (1 psi = 6.895 kPa) for internal iliac arteriography to identify the prostatic artery preliminarily. A 2.6-F Stride microcatheter (Asahi, Japan) was inserted super-selectively into the prostatic artery using the coaxial microcatheter technique. The microcatheter's location, the prostatic artery's course, and surrounding traffic branches were clarified using imaging. The prostatic arteries (PA) were embolized bilaterally by slowly injecting 100–300 µm tripropylene gelatin microspheres (Embosphere, Merit Medical Systems, USA) and an appropriate amount of gelatin sponge particles through a microcatheter. The end-point of embolization was complete retention of the contrast agent in the prostate gland. The microcatheter was withdrawn, and another internal iliac artery angiogram was performed to assess the extent of the embolism and to observe the presence of other collateral blood supply. The procedure was concluded after confirming that there was no staining in the prostate parenchyma, and the puncture site was dressed with pressure and bed rest for 6–8 h. A successful PAE technique was defined as bilateral super-selective cannulation and embolization of the prostatic artery. Based on Tang et al.'s research,(3) TURP was performed on day three after PAE.

Data collection

Data were collected preoperatively (baseline), intraoperatively, postoperatively, and at 3-, 6-, 12-, and 24-months of follow-up. Preoperative data included the patient's age, diabetes mellitus, high blood pressure, body mass index, prostate-specific antigen (PSA), PV assessed by magnetic resonance imaging, postvoid residual urine (PVR) volume assessed by ultrasound, IPSS, QoL Score, National Institutes of Health-Chronic Prostatitis Symptom Index (NIH-CPSI), International Index of Erectile Function Short Form 5, maximum urinary flow rate (Qmax) by free-flowmetry, and detrusor pressure of maximum urinary flow rate (PdetQmax). Intraoperative and postoperative metrics included American Society of Aneshesiologists (ASA) scores, operative time, the weight of tissue removed, speed of lesion removal, intraoperative blood loss (the blood loss was calculated at the end of TURP as the product of irrigating fluid volume and haemoglobin content divided by the preoperative blood haemoglobin concentration [7]), postoperative bladder irrigation time, postoperative catheter retention time, length of hospital stay, cost (including surgery costs, hospital costs, anesthesia, drugs and others), and Clavien-Dindo System grading.[8] All follow-up visits were conducted during urology clinic hours, and patients completed surveys before the clinic visit without the physician. The metrics recorded at each visit included adverse events based on the improved Clavien system, the Common Terminology Criteria for Adverse Events (CTCAE),[4] and the baseline metrics used to assess efficacy. Urodynamic measurements were performed at baseline and the 6-, 12-, and 24-month postoperative follow-ups. Maximum urinary flow rate tests were substituted in the third postoperative month to assess the effects of surgery.

Statistical analysis

GraphPad Prism 9 and SPSS 26 were used for statistical analysis. R (4.2.1) was used to calculate sample size. Quantitative data were expressed as mean ± standard deviation, and the Mann-Whitney *U*-test was used to compare means between groups. Count data were expressed as frequencies (%), and the chi-square test and Fisher's exact test were used to compare groups. For IPSS and QoL 24 months after surgery, the extent of improvement in voiding, obstruction, irritation symptoms, and QoL was evaluated using the validity evaluation index. The safety of the procedures was assessed according to the Clavien grading system and the CTCAE. The validity evaluation index was defined as the ratio of the indexes reviewed 24 months after surgery to the preoperative indexes, with ≤ 0.25 rated as excellent, ≤ 0.5 as good, ≤0.75 as average, and > 0.75 as poor. A $p < 0.05$ was considered significantly different.

Table 4. **Comparison of the ratio of parameters of IPSS and QoL at 24 months after operation between PAE+TURP Group (n=52) and TURP Group (n=115).**

Item	Group	Curative effect grade	Case	Percentage(%)	*P*
IPSS score ratio	PAE+TURP	Excellent	17	32.7 %	.002
	Good	35	67.3 %		
	Average	0	0 %		
	Poor	0	0 %		
TURP	Excellent	13	11.3 %		
	Good	99	86.1 %		
	Average	3	2.6 %		
	Poor	0	0 %		
Voiding score ratio	PAE+TURP	Excellent	22	42.3 %	< .001
	Good	30	57.7 %		
	Average	0	0 %		
	Poor	0	0 %		
TURP	Excellent	13	11.3 %		
	Good	97	84.4 %		
	Average	5	4.3 %		
	Poor	0	0 %		
Storage score ratio	PAE+TURP	Excellent	19	36.5 %	.039
	Good	33	64.5 %		
	Average	0	0 %		
	Poor	0	0 %		
TURP	Excellent	22	19.1 %		
	Good	91	79.1 %		
	Average	2	1.7 %		
	Poor	0	0 %		
QoL	PAE+TURP	Excellent	16	30.8 %	.012
	Good	35	67.3 %		
	Average	1	1.9 %		
	Poor	0	0 %		
TURP	Excellent	16	13.9 %		
	Good	82	71.3 %		
	Average	16	13.9 %		
	Poor	1	0.9 %		

Abbreviations: PAE, prostate artery embolization; TURP, transurethral resection of the prostate; IPSS, international prostate symptom score; QoL, quality of life

RESULTS

Baseline characteristics

According to the calculation result of R, the minimum sample size was 50.[9] Patient inclusion and distribution during follow-up (including reasons for data deletion) are illustrated in a flow chart (**Figure 1**). The average ages of patients in the PAE + TURP and TURP groups were 73.49 ± 8.48 and 72.47 ± 7.12 years, respectively. Preoperative PSA, PV, PVR, Qmax, PdetQmax, IPSS scores, QoL scores, or other baseline data were similar between groups (*P* > 0.05, **Table 1**).

Safety and complications

There were no deaths in the perioperative period in either group. Postoperatively, there were 100 adverse events in the PAE + TURP group and 256 in the TURP group (**Table 2**). The distribution of adverse events in terms of severity was similar between the groups (P = 0.984, Table 2). Clavien grades ≤ II and ≥ III accounted for 96.7 % and 3.3 % of the patients, respectively, and the number of complications with Clavien grades ≥ III occurred in two and five cases, respectively, in both groups (*P* = 0.984, **Table 3**).

Comparison of clinical data

Compared with the TURP group, the PAE + TURP group had shorter operative time (68.56 ± 14.98 min vs. 128.40 ± 27.51 min, *P* < 0.001), faster resection of the adenoma (73.34 ± 8.14 g/h vs. 45.33 ± 7.06 g/h, *P* < 0.001), less intraoperative blood loss (34.02 ± 14.91 mL vs. 65.87 ± 43.94 mL, *P* < 0.001), less postoperative bladder irrigation time (1.66 ± 0.87 days vs. 2.43 ± 1.38 days, *P* < 0.001) and catheter retention time (7.59 ± 2.04 days vs. 9.11 ± 3.48 days, *P* = 0.011); however, the costs of PAE + TURP were higher relative to TURP alone (42369.71 ± 13722.51 RMB vs. 26214.28 ± 6910.75 RMB, P < 0.001). In contrast, the ASA scores, weight of resected tissue and length of hospital stay were similar between two groups (*P* > 0.05, **Table 3**).

Comparison of follow-up metrics

From baseline to 24-months post-surgery in both groups, IPSS, QoL, NIH-CPSI, PV, PVR volume, Qmax, PdetQmax, PSA, and urodynamic obstruction (ICS) were markedly better relative to baseline (**Figure 2**). At 3-months post-surgery, both groups' IPSS scores and Qmax (*P* > 0.05) were similar. However, at 6-, 12-, and 24-months post-surgery, the IPSS scores and Qmax were significantly lower in the PAE + TURP group than in the TURP group (*P* < 0.05, Figure 2A and 2G). At 3-, 6-, and 12-months post-surgery, the QoL scores between the two groups were similar (P > 0.05). However, at 24-months, the QoL scores in the PAE + TURP group were significantly lower than those in the TURP group (*P* < 0.05, **Figure 2B**). The NIH-CPSI scores in the PAE + TURP group were significantly higher than those in the TURP group at 3-, 6-, and 12-months post-surgery (*P* < 0.05). The NIH-CPSI scores were similar between the groups at 24-months (*P* > 0.05, **Figure 2C**). The PV was significantly lower in the PAE + TURP group than in the TURP group at 3-, 6-, 12-, and 24-months (*P* < 0.05, **Figure 2E**). The International Index of Erectile Function Short Form 5 score and PVR volume were similar between the groups (*P* > 0.05, Figures 2D and 2F). There was no apparent discrepancy in PSA between the two groups at 3- and 6-months post-surgery (*P* > 0.05), whereas PSA in the TURP group was significantly higher than those in the PAE + TURP group at 12- and 24-months post-surgery

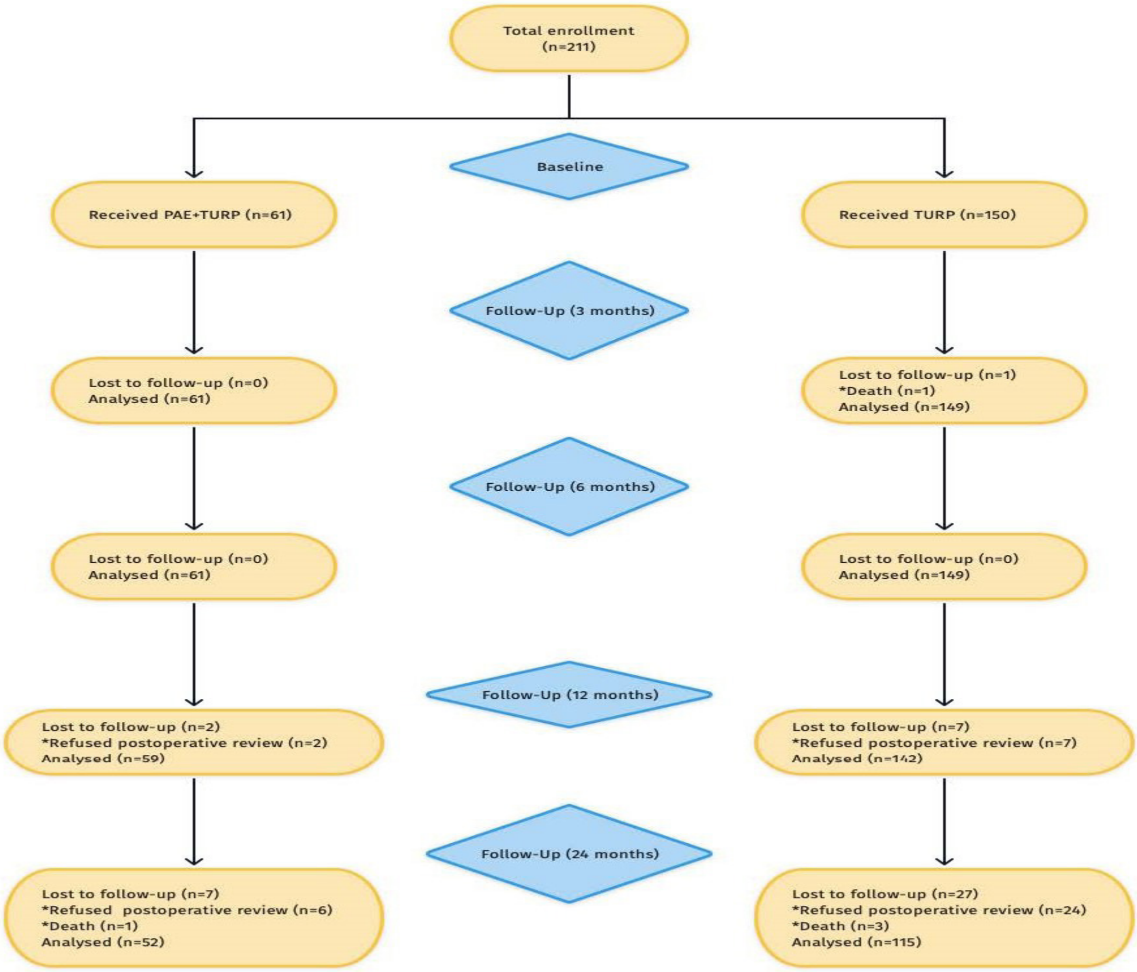

Figure 1. Flow chart of the distribution of patients during the study period. PAE, prostatic artery embolization; TURP, transurethral resection of the prostate.

($P < 0.05$, **Figure 2I**). Finally, PdetQmax and ICS were similar between the two groups at 6-months post-surgery ($P > 0.05$); however, the values were better in the PAE + TURP group than in the TURP group at 12- and 24- months ($P < 0.05$, **Figure 2H and 2J**).

Validity evaluation

At 24-months post-surgery, 167 patients in both groups showed apparent improvement in the IPSS and QoL scores compared with baseline values ($P < 0.05$, Table 4). Although the IPSS and QoL scores increased in both groups at 12-months post-surgery, the PAE + TURP group showed significantly better improvement than the TURP group in total IPSS scores, voiding period, storage period, and QoL scores ($P < 0.05$). The PAE + TURP group showed more significant improvement in voiding symptoms than in storage symptoms, with 42.3% and 36.5% rated excellent, respectively. However, the opposite was true for the TURP group, with 11.3% and 19.1% being rated excellent.

DISCUSSION

BPH is the most common reason for LUTS in middle-aged and older men. Furthermore, approximately 25–60% of men will suffer from BPH during their lifetime,[(10)] and 25% will suffer from moderate-to-severe LUTS, characterized by urinary voiding and storage problems.[(11)] The initial treatment regimen for BPH is usually pharmacological, with alpha-blockers and 5-alpha-reductase inhibitors being the drugs of choice.[(12)] Despite advances in modern drug therapy, 30% of 40-year-old men who live to age 80 undergo surgery because of failure of drug therapy.[(13]) Following European or American urological guidelines, TUIP (transurethral incision of the prostate) is recommended for PV less than 30 cm3,[(14-15)] while TURP is the gold standard for patients with a prostate volume of less than 80 mL and moderate-to-severe LUTS secondary to prostate obstruction.[(15)]. In recent decades, TURP has shown promising clinical efficacy; however, it is accompanied by several complications, including the need for blood transfusion (2.0–8.4%),[(16-17)] retrograde ejaculation (23%),(18) urinary incontinence (3%),(19) urinary tract infection (7.7%),[(18)] urethral stricture (6.2%),[(18)] and transurethral resection syndrome (0.8–1.4%).[(16-17)] For patients with larger PV, TURP may not resect all hyperplastic tissue completely, and there is a high risk of complications and postoperative recurrence.[(20)] Traditionally, open prostatectomy has been chosen to treat large BPH; however, most middle-aged and elderly BPH patients, especially high-risk patients, have difficulty tolerating this procedure. Anesthesia and postoperative complications are the primary problems faced by elderly patients with large glands and multi-

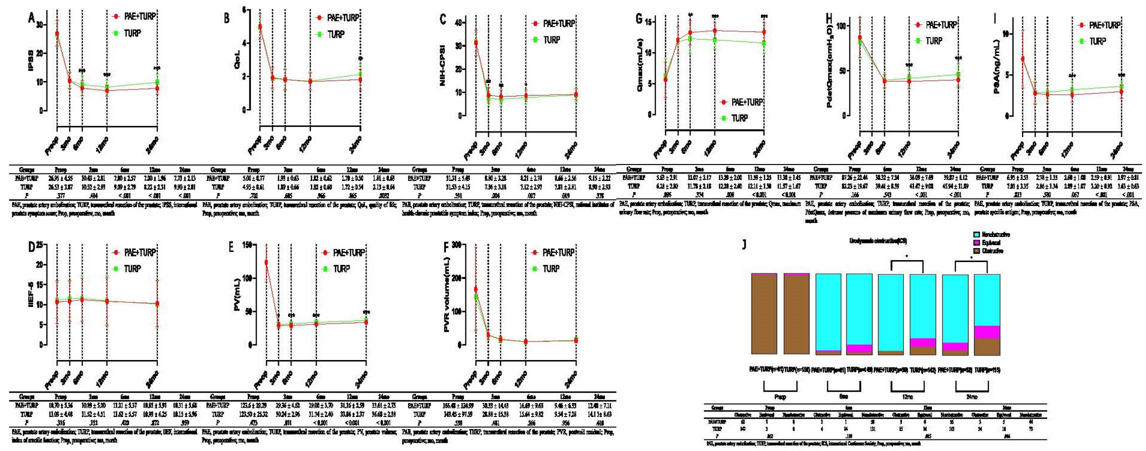

Figure 2. Time course of parameters of urodynamics. A. IPSS, B. QoL, C. NIH-CPSI, D. IIEF-5, E. PV, F. PVR volume, G. Qmax, H. PdetQmax, I.PSA, J. Urodynamic obstruction(ICS). Points were showed as mean and standard deviation. The number of enrolled patients varied with the changes of the follow-up visits and there were 61 patients in PAE+TURP Group and 150 patients in TURP Group at baseline, 61 patients in PAE+TURP Group and 149 patients in TURP Group at 3-month visit, 61 patients in PAE+TURP Group and 149 patients in TURP Group at 6-month visit, 59 patients in PAE+TURP Group and 142 patients at 12-month visit, 52 patients in PAE+TURP Group and 115 patients in TURP Group at 24-month visit. *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

ple underlying diseases such as coronary artery disease and cerebral infarction, for whom the choice of surgical approach remains unclear.[21] And our study provides some reference for clinical urologists in choosing surgical options for patients with large-volume prostate.

In recent years, minimally invasive interventional procedures have been used to prevent or treat bleeding before and after prostate surgery because there is less trauma, lower risk, faster recovery, and no need for general anesthesia.[21] PAE is emerging as a preferred minimally invasive therapy, with data published on more than 1,000 PAE cases showing clinical outcomes similar to those of TURP.[22] Theurich et al.[11] showed that 24 months after PAE, there was a 21%, 44%, and 55% reduction in PV, PVR and IPSS, respectively. Additionally, the authors noted significant improvements in QoL (60%), storage (–50%), and voiding (–58%) symptoms ($P < 0.001$).[10] A recent meta-analysis[15] of six high-quality randomized controlled studies showed that PAE does not improve PV and Qmax as much as TURP; however, it generates similar improvements in IPSS, QoL, PSA, and PV, with a lower incidence of sexual dysfunction. These findings suggest that PAE could be an alternative therapy for patients with BPH who are unwilling to undergo surgery or have contraindications to surgery. Patients with BPH have increased levels of angiogenic factors in the glandular tissues and increased microvascular density, which leads to the proliferation of prostatic interstitial cells, which leads to less urinary tract obstruction. PAE causes local tissue ischemia and hypoxia by selective embolization of the PA, which decreases plasma testosterone levels and reduces smooth muscle alpha-adrenergic receptors, leading to decreased PV and bladder neck relaxation, ultimately relieving LUTS.[23-24]

Although PAE treats prostate bleeding and severe LUTS, it does not entirely alleviate bladder outlet obstruction caused by a large gland. Because if this, many patients (21%) undergo more invasive therapy within 24 months after PAE owing to unsatisfactory outcomes.[3] From these lines of evidence, the choice of PAE as the first-line therapy option for BPH remains controversial. In the current study, we performed PAE before TURP to help reduce intraoperative bleeding, shorten operation time and minimize postoperative complications for patients with advanced age, underlying disease, or coagulation disorders. Few studies have reported the combination of TURP and PAE, and there is an absence of large-scale and long-term studies to assess this therapy's sustained efficacy and safety in treating giant (≥ 100 mL) prostate enlargement.

The PA is small in diameter (approximately 0.5–2.0 mm) and has a complex origin, including the subvesical artery, the inferior rectal artery, the internal pudendal artery, the obturator artery, and the vas deferens arteries. The subvesical artery is the most common, followed by the inferior rectal artery.[25] The key to PAE for BPH is highly dependent on the precise recognition and embolization of the PA. Middle-aged and elderly patients often have severe arteriosclerosis, resulting in tortuous and narrowed vessels that cause PAE procedures to fail or necessitate unilateral embolization. For these patients, the efficacy of unilateral PAE is worse than that of bilateral PAE, and postoperative prostate collateral vessel reconstruction and residual prostate tissue regeneration can lead to re-obstruction of the prostate.[26] For this reason, only patients with successful bilateral PA embolization were included in this study to reduce bias and improve the accuracy of our results. Common complications after PAE include hematuria, urinary retention, urinary tract infection, and ischemia of the bladder wall and glans penis; however, these complications do not require surgical correction and usually self-resolve.[13]

A recent small retrospective analysis by Tang et al.[3] with limited follow-up showed better outcomes, safer and fewer postoperative complications of PAE + TURP for treating patients with giant BPH than TURP alone. However, this study had a small sample size and lacked reliable long-term follow-up data; therefore, the long-term treatment effect of PAE + TURP to treat large BPH remains questionable. Our study has several significant findings beyond the study conducted by Yang et al.[3] First, the PAE + TURP group had lower operative time, intraoperative blood loss, postoperative bladder irrigation time, and catheter retention time than the TURP group, while the speed of lesion resection and cost were higher than in the TURP group; these findings agree with the previous studies.[7] Our findings suggest that TURP combined with PAE therapy (despite the higher expense) can reduce intraoperative bleeding and lower the risk of surgery, making the procedure faster and resulting in a shorter postoperative recovery time. The reason for longer catheterization time than that in literature[27] on TURP of our study is to prevent secondary bleeding caused by premature removal of catheter and reduce the probability of postoperative urethral stricture. Second, at 24 months post-surgery, the PAE + TURP regimen showed significantly better IPSS, QoL, PV, Qmax, PSA, and ICS than the TURP group. Additionally, compared to the TURP group, the validity evaluation index showed a more significant improvement in IPSS and QoL postoperative scores in the PAE + TURP group relative to baseline, demonstrating the satisfactory long-term results of PAE + TURP in patients with giant BPH. Finally, we found a comparable distribution of postoperative adverse event severity classes in the PAE + TURP and TURP alone groups, suggesting that PAE as a preoperative adjunctive therapy has a minor impact on postoperative complications after TURP; this finding was not reported in previous studies.

To note, with the rapid development of modern surgical armamentarium of BPH surgery,[28] endoscopic enucleation of the prostate (EEP) techniques, such as holmium laser enucleation of the prostate (Holep),[29] were reported to show the ability to surpass TURP both in outcomes and safety for giant prostates, implying the use of more choices for patients with giant BPH.

Our study has some limitations. First, this single-center study included a relatively small sample that may not reflect key sociographic clinical differences. Second, the follow-up time of our study was short. Future studies should follow up patients for at least 5 years to fully assess the long-term efficacy of treatment. Lastly, we only compared the differences in the outcomes between TURP and PAE + TURP, while Theurich et al.[10] reported that only PAE could help improve voiding and storage symptoms. Due to the limitations of this study, these data must be validated in long-term, multicenter, prospective clinical controlled trials. Moreover, we will compare differences between PAE, TURP, and PAE + TURP in future studies.

CONCLUSIONS

In summary, our research indicates that PAE + TURP is a more suitable surgical option for patients with large-volume prostate (> 100 mL) than TURP alone. It can accelerate recovery and significantly improve postoperative quality of life without an apparent increase in risk.

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CONFLICT OF INTEREST

The authors report no conflict of interest.

REFERENCES

1. Langan RC. Benign Prostatic Hyperplasia. Prim Care. 2019;46:223-32.
2. Capdevila F, Insausti I, Galbete A, Sanchez-Iriso E, Montesino M. Prostatic Artery Embolization Versus Transurethral Resection of the Prostate: A Post Hoc Cost Analysis of a Randomized Controlled Clinical Trial. Cardiovasc Intervent Radiol. 2021;44:1771-7.
3. Tang Y, Wang RL, Ruan DD, et al. Retrospective observation of the efficacy and safety of prostatic artery embolization combined with transurethral resection of the prostate and simple transurethral resection of the prostate in the treatment of large (>100 mL) benign prostatic hyperplasia. Abdom Radiol (NY). 2021;46:5746-57.
4. Abt D, Müllhaupt G, Hechelhammer L, et al. Prostatic Artery Embolisation Versus Transurethral Resection of the Prostate for Benign Prostatic Hyperplasia: 2-yr Outcomes of a Randomised, Open-label, Single-centre Trial. Eur Urol. 2021;80:34-42.
5. Lebdai S, Chevrot A, Doizi S, et al. Surgical and interventional management of benign prostatic obstruction: Guidelines from the Committee for Male Voiding Disorders of the French Urology Association. Prog Urol. 2021;31:249-65.
6. Ayyagari R, Powell T, Staib L, et al. Prostatic Artery Embolization Using 100-300-µm Trisacryl Gelatin Microspheres to Treat Lower Urinary Tract Symptoms Attributable to Benign Prostatic Hyperplasia: A Single-Center Outcomes Analysis with Medium-Term Follow-up. J Vasc Interv Radiol. 2020;31:99-107.
7. Ekengren J, Hahn RG. Blood loss during transurethral resection of the prostate as measured by the HemoCue photometer. Scand J Urol Nephrol. 1993;27:501-7.
8. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004;240:205-13.
9. Chow S, Shao J, Wang H. Sample Size Calculations in Clinical Research (2nd Ed.). Chapman & Hall/CRC Biostatistics Series; 2008. page 61.
10. Knight GM, Talwar A, Salem R, Mouli S. Systematic Review and Meta-analysis Comparing Prostatic Artery Embolization to Gold-Standard Transurethral Resection of the Prostate for Benign Prostatic Hyperplasia. Cardiovasc Intervent Radiol. 2021;44:183-93.
11. Theurich AT, Leistritz L, Leucht K, et al. Influence of Prostate Artery Embolization on Different Qualities of Lower Urinary Tract Symptoms Due to Benign Prostatic Obstruction. Eur Urol Focus. 2022;8:1323-30.
12. Xu XF, Liu GX, Zhu C, et al. α1-Blockers and 5α-Reductase Inhibitors Are the Most

Recommended Drugs in Treating Benign Prostatic Hyperplasia: An Evidence-Based Evaluation of Clinical Practice Guidelines. Front Pharmacol. 2020;11:311.
13. Neymark AI, Karpenko AA, Neymark BA, et al. Superselective prostatic artery embolization in the treatment of large benign prostatic hyperplasia. Urologia. 2021;88:374-81.
14. Sarier M, Duman I, Kilic S, et al. Comparative Results of Transurethral Incision with Transurethral Resection of The Prostate in Renal Transplant Recipients with Benign Prostate Hyperplasia. Urol J. 2018;15:209-213.
15. Xu Z, Zhou Z, Mu Y, Cai T, Gao Z, Liu L. An Updated Meta-Analysis of the Efficacy and Safety of Prostatic Artery Embolization vs. Transurethral Resection of the Prostate in the Treatment of Benign Prostatic Hyperplasia. Front Surg. 2021;8:779571.
16. Reich O, Gratzke C, Bachmann A, et al. Morbidity, mortality and early outcome of transurethral resection of the prostate: a prospective multicenter evaluation of 10,654 patients. J Urol. 2008;180:246-9.
17. Ahyai SA, Lehrich K, Kuntz RM. Holmium laser enucleation versus transurethral resection of the prostate: 3-year follow-up results of a randomized clinical trial. Eur Urol. 2007;52:1456-63.
18. Gilling P, Barber N, Bidair M, et al. Three-year outcomes after Aquablation therapy compared to TURP: results from a blinded randomized trial. Can J Urol. 2020;27:10072-9.
19. Bachmann A, Tubaro A, Barber N, et al. A European multicenter randomized noninferiority trial comparing 180 W GreenLight XPS laser vaporization and transurethral resection of the prostate for the treatment of benign prostatic obstruction: 12-month results of the GOLIATH study. J Urol. 2015;193:570-8.
20. Suskind AM, Walter LC, Zhao S, Finlayson E. Functional Outcomes After Transurethral Resection of the Prostate in Nursing Home Residents. J Am Geriatr Soc. 2017;65:699-703.
21. Bilhim T, Bagla S, Sapoval M, Carnevale FC, Salem R, Golzarian J. Prostatic Arterial Embolization versus Transurethral Resection of the Prostate for Benign Prostatic Hyperplasia. Radiology. 2015;276:310-1.
22. Insausti I, Sáez de Ocáriz A, Galbete A, et al. Randomized Comparison of Prostatic Artery Embolization versus Transurethral Resection of the Prostate for Treatment of Benign Prostatic Hyperplasia. J Vasc Interv Radiol. 2020;31:882-90.
23. Sun F, Crisóstomo V, Báez-Díaz C, Sánchez FM. Prostatic Artery Embolization (PAE) for Symptomatic Benign Prostatic Hyperplasia (BPH): Part 2, Insights into the Technical Rationale. Cardiovasc Intervent Radiol. 2016;39:161-9.
24. Noor A, Fischman AM. Prostate Artery Embolization as a New Treatment for Benign Prostate Hyperplasia: Contemporary Status in 2016. Curr Urol Rep. 2016;17:51.
25. Moya C, Cuesta J, Friera A, Gil-Vernet Sedó JM, Valderrama-Canales FJ. Cadaveric and radiologic study of the anatomical variations of the prostatic arteries: A review of the literature and a new classification proposal with application to prostatectomy. Clin Anat. 2017;30:71-80.
26. Tang Y, Zhang JH, Zhu YB, et al. Effect of superselective prostatic artery embolization on benign prostatic hyperplasia. Abdom Radiol (NY). 2021;46:1726-36.
27. Sun F, Sun X, Shi Q, Zhai Y. Transurethral procedures in the treatment of benign prostatic hyperplasia: A systematic review and meta-analysis of effectiveness and complications. Medicine (Baltimore). 2018;97(51):e13360.
28. Reichelt AC, Suarez-Ibarrola R, Herrmann TRW, Miernik A, Schöb DS. Laser procedures in the treatment of BPH: a bibliometric study. World J Urol. 2021;39:2903-11.
29. Das AK, Teplitsky S, Humphreys MR. Holmium laser enucleation of the prostate (HoLEP): a review and update. Can J Urol. 2019;26(4 Suppl 1):13-19.