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ORIGINAL RESEARCH

Efficacy and safety of prostate artery embolization on lower urinary tract symptoms related to benign prostatic hyperplasia: a systematic review and meta-analysis

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Xiao-yan Wang
Huan-tao Zong
Yong Zhang

Department of Urology, Beijing Tian Tan Hospital, Capital Medical University, Beijing, People's Republic of China

Background: Prostate artery embolization (PAE) is emerging and is a promising minimally invasive therapy that improves lower urinary tract symptoms (LUTS) related to benign prostatic hyperplasia (BPH). The purpose of this article was to evaluate the efficacy and safety of PAE on LUTS related to BPH.

Materials and methods: A literature review was performed to identify all published articles of PAE for BPH. The sources included MEDLINE, EMBASE and Cochrane Library from 1980 to 2016. A systematic review and meta-analysis was conducted. The outcome measurements were combined by calculating the mean difference with 95% confidence interval. Statistical analysis was carried out using Review Manager 5.3.0.

Results: Twelve studies involving 840 participants were included. Compared with baseline, the International Index of Erectile Function (IIEF-5; International Prostate Symptom Score) scores, the quality of life scores, peak urinary flow rate (Q_{max}) and postvoid residual volume all had significant improvements during the 24-month follow-up (all $P<0.00001$). Both prostate volume (PV) and prostate-specific antigen had significant decrease during the 12-month follow-up ($P<0.00001$ and $P=0.005$, respectively), except postoperative 24 months ($P=0.47$ and $P=0.32$, respectively). The IIEF-5 short form scores had significant increase at postoperative 6 months ($P=0.002$) and 12 months ($P<0.0001$), except postoperative 1 month ($P=0.23$) and 24 months ($P=0.21$). For large volume (PV ≥80 mL) BPH, the results were similar. There were no life-threatening complications.

Conclusion: PAE is an effective, safe and well-tolerable treatment for LUTS related to BPH, including large volume (PV ≥80 mL) 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.

Keywords: lower urinary tract symptoms, benign prostatic hyperplasia, meta-analysis, prostate artery embolization

Introduction

Lower urinary tract symptoms (LUTS) are main complaints resulting from benign prostatic hyperplasia (BPH), which is one of the most common diseases of aging men.[1] LUTS can range in severity and have a significant impact on the quality of life (QoL).

The current treatment options include watchful waiting, medical therapy and surgical intervention. The patients refractory to preliminary treatments can be treated with surgical intervention. Transurethral resection of the prostate (TURP) is the gold standard therapy for LUTS/BPH and, for many years, has been considered the surgical treatment

Correspondence: Yong Zhang
Department of Urology, Beijing Tian Tan Hospital, Capital Medical University, No 6 Tiantan Xi Li, Dong Cheng District, Beijing 100050, People's Republic of China
Tel +86 10 6709 8393
Fax +86 10 6709 6611
Email 18610711834@163.com

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of choice and the standard of care when other treatment methods fail.[2] However, TURP has significant complications, including short-term bleeding, dilutional hyponatremia, sexual dysfunction and incontinence. The complication rate is higher for patients with large volume BPH.[3]

Recently, prostate artery embolization (PAE) has started emerging and is a promising minimally invasive therapy that improves LUTS related to BPH and is associated with a decrease in prostate volume (PV).[4] However, it is reported that as many as 25% of patients show no significant improvement in symptoms and peak flow rate. In addition, the average reduction rate in the PV after PAE was only 20%.[5]

The aim of this meta-analysis was to evaluate the efficacy and safety of PAE on LUTS related to BPH, which may help urologists make better choices in the case of elderly patients with large volume BPH.

Materials and methods

Search strategy

A comprehensive literature search was carried out by two independent reviewers using MEDLINE (from 1980 to 2016), EMBASE (from 1980 to 2016) and the Cochrane Central Register of Controlled Trials. The reference lists of the retrieved studies were also checked. The following search terms were used: "prostate artery embolization", "lower urinary tract symptoms" and "benign prostatic hyperplasia".

Inclusion criteria

Studies that met the following criteria were included: 1) a study design that included PAE for BPH; 2) a study that provided data on International Prostate Symptom Score (IPSS), QoL, PV, prostate-specific antigen (PSA), peak urine flow rate (Q_{max}), postvoid residual (PVR) volume and International Index of Erectile Function (IIEF-5) short form at different follow-up times, and 3) a study where its full text could be accessed. If these inclusion criteria were not met, then the study was excluded.

Trial selection

When the same study was published in various journals or in different years, the most frequently cited one was used. If the same group of researchers studied a group of subjects with multiple experiments, then each study was included. Together, we discussed each of the studies that were included and excluded.

Quality assessment

The quality of included studies was assessed using the Newcastle–Ottawa scale generating a maximum of nine stars to each study, including four stars for the selection of participants, two stars for the comparability of participants and three stars for the assessment of outcomes. Quality was assigned according to the scores so that seven to nine stars indicated high quality, four to six stars indicated middle quality and zero to three stars indicated low quality.

Data extraction

Two independent reviewers extracted the data using a predesigned form. The following information was collected from each study: 1) the name of the first author and the publication year; 2) the sample size; 3) the country in which the study was conducted; 4) data on IPSS, QoL, PV, PSA, Q_{max}, PVR volume and IIEF-5 at different follow-up times and 5) the number of participants with complications. Any disputes were resolved by group consensus.

Statistical analysis

Statistical analysis was carried out using Review Manager 5.3.0. The changes in seven functional indexes were determined as differences between baseline and study completion. Outcome measurements were combined by calculating the mean difference with 95% confidence interval (CI). To quantify the effect of heterogeneity test result, I^2 heterogeneity test was used. A random-effects model was used if I^2 value was $>50\%$; if not, a fixed-effects model was used. Publication bias was evaluated using the funnel plot.

Results

Characteristic and quality assessment of eligible studies

Figure 1 shows the flow diagram of the study selection process. Finally, there were nine articles involving 12 studies eligible for this meta-analysis.[6–14] All of the 12 studies reported the baseline IPSSs, QoL scores, PV, PSA levels, Q_{max}, PVR volume and IIEF-5 scores. All 12 studies excluded patients with malignancy, advanced atherosclerosis and tortuosity of the iliac arteries and/or prostate arteries, secondary renal insufficiency, large bladder diverticula or stones, neurogenic bladder, detrusor muscle failure, active urinary tract infection and unregulated coagulation parameters. The main characteristic and quality assessment of eligible studies are presented in Table 1.

Changes after PAE

IPSSs

Six studies involving 582 participants, five studies involving 451 participants, six studies involving 479 participants and three studies involving 117 participants included

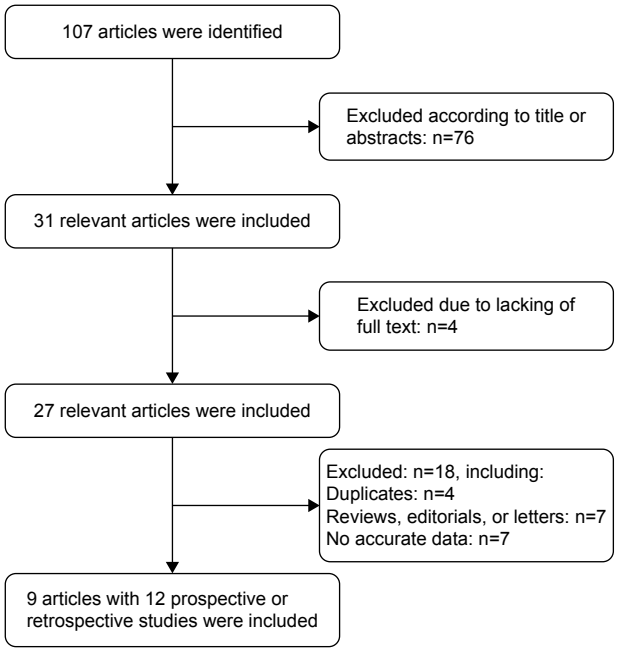

Figure 1 The flow diagram of the study selection process.

data representing IPSS changes at postoperative 1 month (Figure 2A), 6 months (Figure 2B), 12 months (Figure 2C) and 24 months (Figure 2D), respectively.

Compared with baseline, the IPSSs had significant decreases at postoperative 1 month (weighted mean difference (WMD) −12.74, 95% CI −15.10 to −10.39, $P<0.00001$), 6 months (WMD −14.13, 95% CI −17.73 to −10.54, $P<0.00001$), 12 months (WMD −16.07, 95% CI −18.16 to −13.98, $P<0.00001$) and 24 months (WMD −15.62, 95% CI −17.41 to −13.82, $P<0.00001$).

QoL scores

Nine studies involving 660 participants, eight studies involving 528 participants, six studies involving 414 participants and three studies involving 117 participants included data representing QoL score changes at postoperative 1 month (Figure 3A), 6 months (Figure 3B), 12 months (Figure 3C) and 24 months (Figure 3D), respectively.

Compared with baseline, the QoL scores had significant decreases at postoperative 1 month (WMD −2.07, 95% CI −2.37 to −1.76, $P<0.00001$), 6 months (WMD −2.15, 95% CI −2.44 to −1.86, $P<0.00001$), 12 months (WMD −2.81, 95% CI −3.45 to −2.17, $P<0.00001$) and 24 months (WMD −2.15, 95% CI −2.60 to −1.69, $P<0.00001$).

Prostate volume

Five studies involving 507 participants, five studies involving 386 participants, six studies involving 366 participants and three studies involving 106 participants included data representing PV changes at postoperative 1 month (Figure 4A), 6 months (Figure 4B), 12 months (Figure 4C) and 24 months (Figure 4D), respectively.

Compared with baseline, PV had significant decreases at postoperative 1 month (WMD −17.33, 95% CI −21.19 to −13.47, $P<0.00001$), 6 months (WMD −31.62, 95% CI −46.75 to −16.48, $P<0.0001$) and 12 months (WMD −30.72, 95% CI −42.91 to −18.53, $P<0.00001$). Although PV was also less at postoperative 24 months (WMD −16.89, 95% CI −62.61 to −28.83), the difference was not statistically significant ($P=0.47$).

Prostate-specific antigen

Five studies involving 520 participants, five studies involving 383 participants, six studies involving 379 participants and three studies involving 104 participants included data representing PSA changes at postoperative 1 month (Figure 5A), 6 months (Figure 5B), 12 months (Figure 5C) and 24 months (Figure 5D), respectively.

Compared with baseline, PSA had significant decreases at postoperative 1 month (WMD −0.80, 95% CI −1.44 to −0.16, $P=0.01$), 6 months (WMD −1.15, 95% CI −1.69 to −0.60, $P<0.0001$) and 12 months (WMD −0.97, 95% CI −1.65 to −0.29, $P=0.005$). Although PSA was also less at postoperative 24 months (WMD −0.80, 95% CI −2.37 to −0.77), the difference was not statistically significant ($P=0.32$).

Q_{max}

Six studies involving 502 participants, five studies involving 368 participants, six studies involving 368 participants and three studies involving 104 participants included data representing Q_{max} changes at postoperative 1 month (Figure 6A), 6 months (Figure 6B), 12 months (Figure 6C) and 24 months (Figure 6D), respectively.

Compared with baseline, Q_{max} had significant increases at postoperative 1 month (WMD 4.40, 95% CI 3.00–5.80, $P<0.00001$), 6 months (WMD 4.71, 95% CI 2.62–6.81, $P<0.0001$), 12 months (WMD 5.60, 95% CI 4.19–7.02, $P<0.00001$) and 24 months (WMD 5.89, 95% CI 5.08–6.7, $P<0.00001$).

PVR volume

Six studies involving 476 participants, five studies involving 348 participants, six studies involving 369 participants and three studies involving 104 participants included data representing PVR volume changes at postoperative 1 month (Figure 7A), 6 months (Figure 7B), 12 months (Figure 7C) and 24 months (Figure 7D), respectively.

Table 1 The main characteristic and quality assessment of eligible studies

Studies	Sample size	Study design	Country	Age (years)	PV (mL)	Other inclusion criteria	Outcome measures	Follow-up (month)	Quality assessment[a]
Gabr et al[6]	22	Retrospective study	Saudi Arabia	>50	N	BPH patients with LUTS refractory to BPH-related medical therapy or those who had an indwelling urethral catheter due to refractory urine retention	IPSS, QoL, PV, PSA, Q_{max}, PVR volume, IIEF-5	1, 3, 9	Four stars
Bilhim et al[7]	186	Retrospective study	Portugal	>55	>30	BPH patients, IPSS >18 and QoL scores ≥3, refractory to medical treatment for at least 6 months; Q_{max} ≤12 mL/s or those with acute urinary retention	IPSS, QoL, PV, PSA, Q_{max}, PVR volume, IIEF-5	1, 6, 12, 18, 24	Seven stars
Wang et al[8]	47	Prospective study	China	≥75	>40	BPH patients, IPSS >18 and QoL scores ≥3, refractory to medical treatment for at least 6 months; Q_{max} ≤12 mL/s or those with acute urinary retention	IPSS, QoL, PV, PSA, Q_{max}, PVR volume, IIEF-5	12	Five stars
Wang et al[8]	100			<75					Seven stars
Isaacson et al[9]	12	Prospective study	USA	>40	80–150	Previous trial of BPH medication, IPSS ≥18, life expectancy >1 year	IPSS, QoL, PV, PSA, Q_{max}, PVR volume, IIEF-5	1, 3	Three stars
Bagla et al[10]	16	Prospective study	USA	>45	<50	BPH patients with moderate- or severe-grade symptoms	QoL, IIEF-5	1, 3, 6	Four stars
Bagla et al[10]	26				50–80				Four stars
Bagla et al[10]	36				>80				Four stars
Li et al[11]	22	Prospective study	China	>65	>80	BPH patients, IPSS >12, Q_{max} <15 mL/s, PSA <4 ng/mL or PSA level between 4 and 10 ng/mL but negative prostate biopsy	IPSS, QoL, PV, PSA, Q_{max}, PVR volume, IIEF-5	1, 3, 6, 12	Four stars
Wang et al[12]	109	Prospective study	China	>50	>80	BPH patients, IPSS >18 and QoL scores >3, refractory to medical treatment for at least 6 months, Q_{max} <12 mL/s	IPSS, QoL, PV, PSA, Q_{max}, PVR volume, IIEF-5	1, 3, 6, 12, 24	Six stars
Pisco et al[13]	250	Prospective study	Portugal	>45	>40	BPH patients, IPSS >18, and QoL score ≥3, refractory to medical treatment for at least 6 months; Q_{max} <12 mL/s, sexual dysfunction or accepting the risk of developing sexual dysfunction after treatment	IPSS, QoL, PV, PSA, Q_{max}, PVR volume, IIEF-5	1, 3, 6, 12, 18, 24	Eight stars
Pisco et al[14]	14	Prospective study	Portugal	>60	N	BPH patients, IPSS >18 and QoL score ≥3, refractory to medical treatment for at least 6 months; Q_{max} <12 mL/s or those with acute urinary retention	IPSS, QoL, PV, PSA, Q_{max}, PVR volume, IIEF-5	6	Three stars

Notes: [a]Seven to nine stars indicated high quality, four to six stars middle quality and zero to three stars low quality. "N" indicates not applicable.

Abbreviations: AUA, American Urological Association Symptom Index; BPH, benign prostatic hyperplasia; IIEF-5, International Index of Erectile Function; IPSS, International Prostate Symptom Score; LUTS, lower urinary tract symptoms; PSA, prostate-specific antigen; PV, prostate volume; PVR, postvoid residual; Q_{max}, peak urinary flow rate; QoL, quality of life.

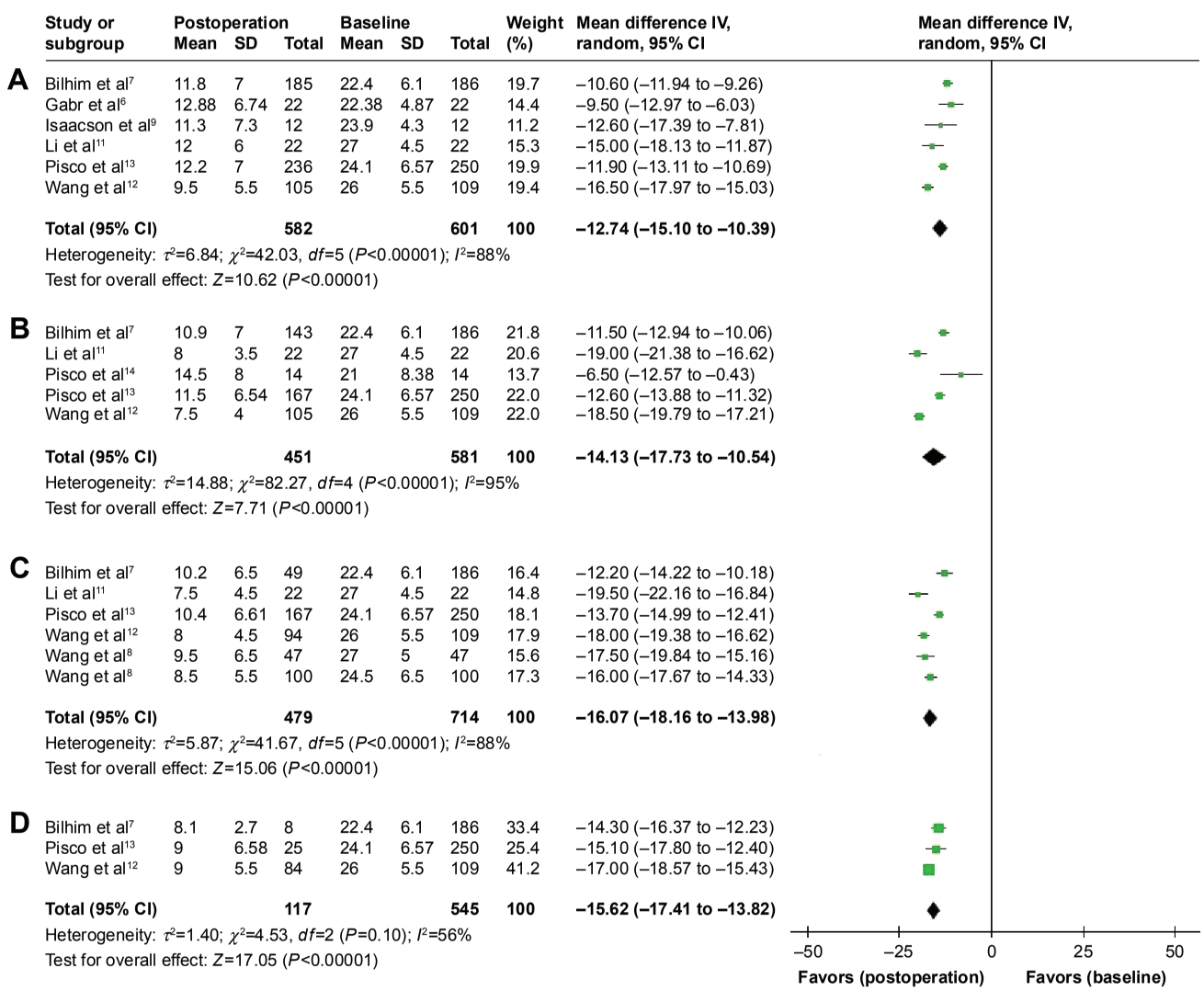

Figure 2 A forest plot about IPSS changes after PAE at postoperative 1 month (**A**), 6 months (**B**), 12 months (**C**), and 24 months (**D**).
Abbreviations: CI, confidence interval; IPSS, International Prostate Symptom Score; IV, intravenous; PAE, prostate artery embolization; SD, standard deviation.

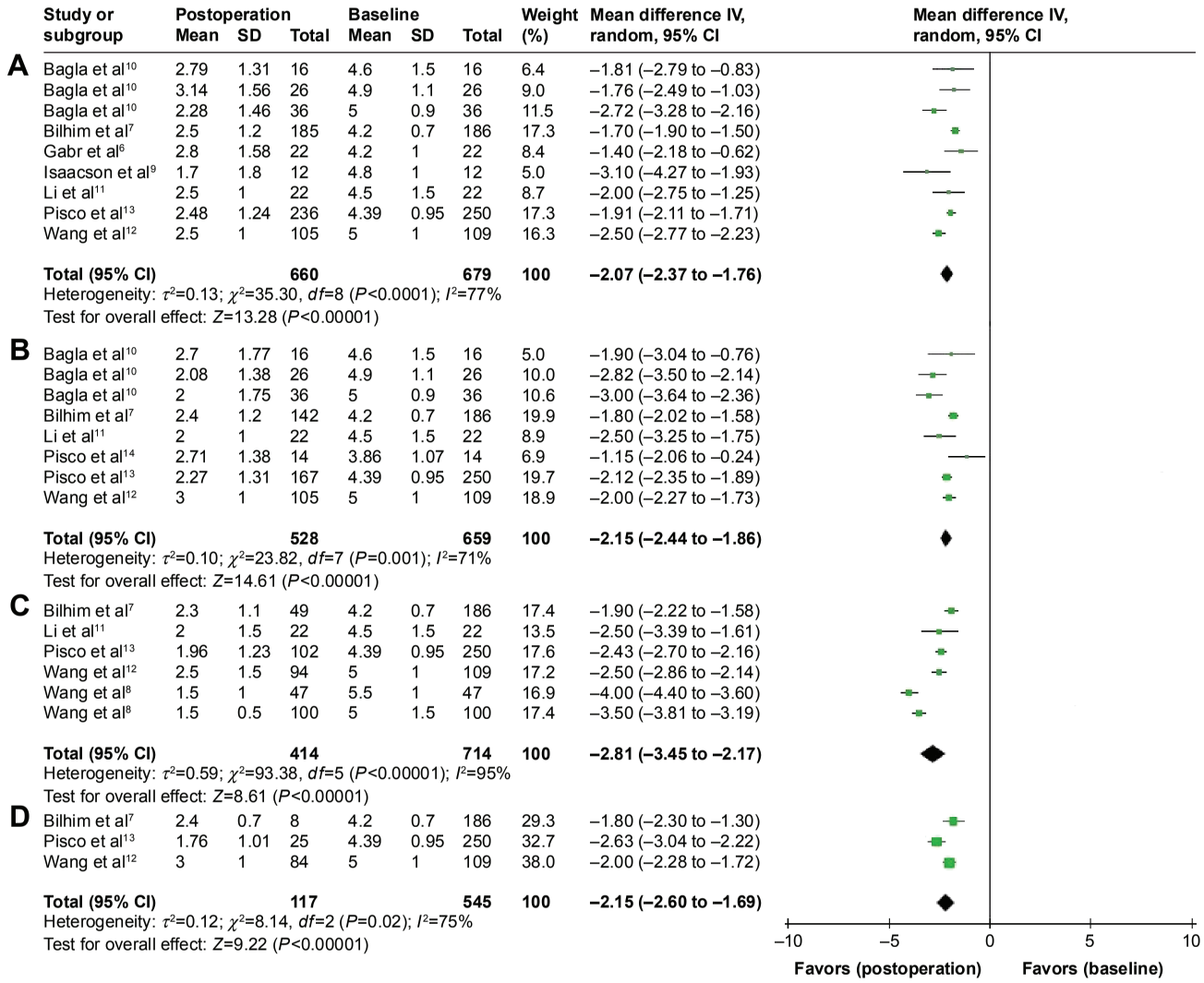

Figure 3 A forest plot about QoL score changes after PAE at postoperative 1 month (**A**), 6 months (**B**), 12 months (**C**), and 24 months (**D**).
Abbreviations: CI, confidence interval; IV, intravenous; PAE, prostate artery embolization; SD, standard deviation; QoL, quality of life.

	Study or subgroup	Postoperation Mean	Postoperation SD	Postoperation Total	Baseline Mean	Baseline SD	Baseline Total	Weight (%)	Mean difference IV, random, 95% CI
A	[a]Bilhim et al[7]	66.6	39.7	175	88.6	51.3	186	16.7	–22.00 (–31.43 to 12.57)
	Gabr et al[6]	56.8	15.77	22	77.3	14.89	22	18.1	–20.50 (–29.56 to 11.44)
	Li et al[11]	100	25	22	110	25	22	6.8	–10.00 (–24.77 to 4.77)
	Pisco et al[13]	66.8	28.75	183	83.5	37	250	38.8	–16.70 (–22.90 to –10.50)
	Wang et al[12]	103.8	30	105	118	35	109	19.6	–14.20 (–22.92 to –5.48)
	Total (95% CI)			**507**			**589**	**100**	**–17.33 (–21.19 to –13.47)**
	Heterogeneity: χ^2=2.89, df=4 (P=0.58); I^2=0%								
	Test for overall effect: Z=8.80 (P<0.00001)								
B	Bilhim et al[7]	66.9	38	134	88.6	51.3	186	21.4	–21.70 (–31.49 to –11.91)
	Li et al[11]	67	25	22	110	25	22	19.2	–43.00 (–57.77 to –28.23)
	Pisco et al[14]	76	27.9	14	104.9	36.3	14	14.8	–28.90 (–52.88 to –4.92)
	Pisco et al[13]	66.8	30.92	111	83.5	37	250	22.3	–16.70 (–24.06 to –9.34)
	Wang et al[12]	70	15	105	118	35	109	22.3	–48.00 (–55.17 to –40.83)
	Total (95% CI)			**386**			**581**	**100**	**–31.62 (–46.75 to –16.48)**
	Heterogeneity: τ^2=253.76; χ^2=42.12, df=4 (P<0.00001); I^2=91%								
	Test for overall effect: Z=4.09 (P<0.0001)								
C	Bilhim et al[7]	71.1	46.2	40	88.6	51.3	186	14.4	–17.50 (–33.60 to –1.40)
	Li et al[11]	69	20	22	110	25	22	15.7	–41.00 (–54.38 to –27.62)
	Pisco et al[13]	66.9	32.54	63	83.5	37	250	17.4	–16.60 (–25.85 to –7.35)
	Wang et al[12]	68.5	15	94	118	35	109	18.1	–49.50 (–56.74 to –42.26)
	Wang et al[8]	50	20	47	86	38	47	16.2	–36.00 (–48.28 to –23.72)
	Wang et al[8]	48.5	15	100	71	31	100	18.2	–22.50 (–29.25 to –15.75)
	Total (95% CI)			**366**			**714**	**100**	**–30.72 (–42.91 to –18.53)**
	Heterogeneity: τ^2=200.17; χ^2=45.92, df=5 (P<0.00001); I^2=89%								
	Test for overall effect: Z=4.94 (P<0.00001)								
D	Bilhim et al[7]	90	85.5	8	88.6	51.3	186	24.1	1.40 (–58.30 to 61.10)
	Pisco et al[13]	90.9	53.4	14	83.5	37	250	35.4	7.40 (–20.95 to 35.75)
	Wang et al[12]	69	18	84	118	35	109	40.5	–49.00 (–56.62 to –41.38)
	Total (95% CI)			**106**			**545**	**100**	**–16.89 (–62.61 to 28.83)**
	Heterogeneity: τ^2=1,328.37; χ^2=16.49, df=2 (P=0.0003); I^2=88%								
	Test for overall effect: Z=0.72 (P=0.47)								

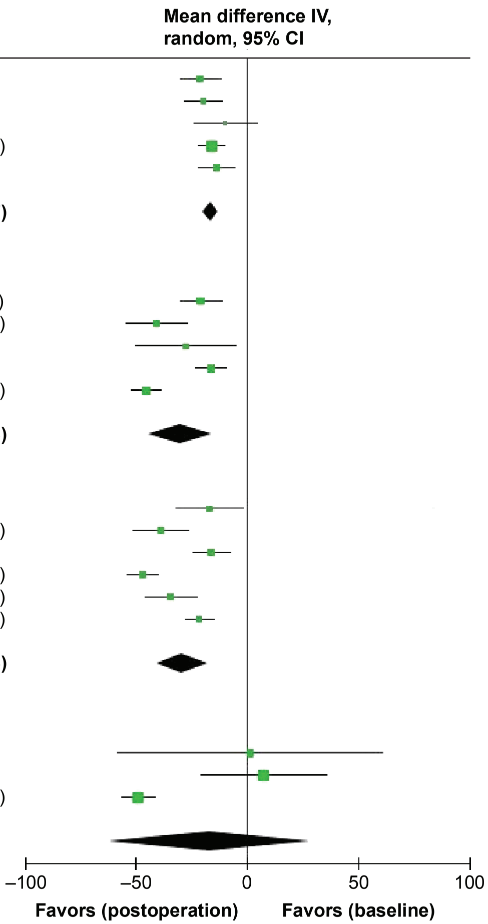

Figure 4 A forest plot about PV changes after PAE at postoperative 1 month (**A**), 6 months (**B**), 12 months (**C**), and 24 months (**D**).
Note: [a]Using the fixed-effects model.
Abbreviations: CI, confidence interval; IV, intravenous; PAE, prostate artery embolization; PV, prostate volume; SD, standard deviation.

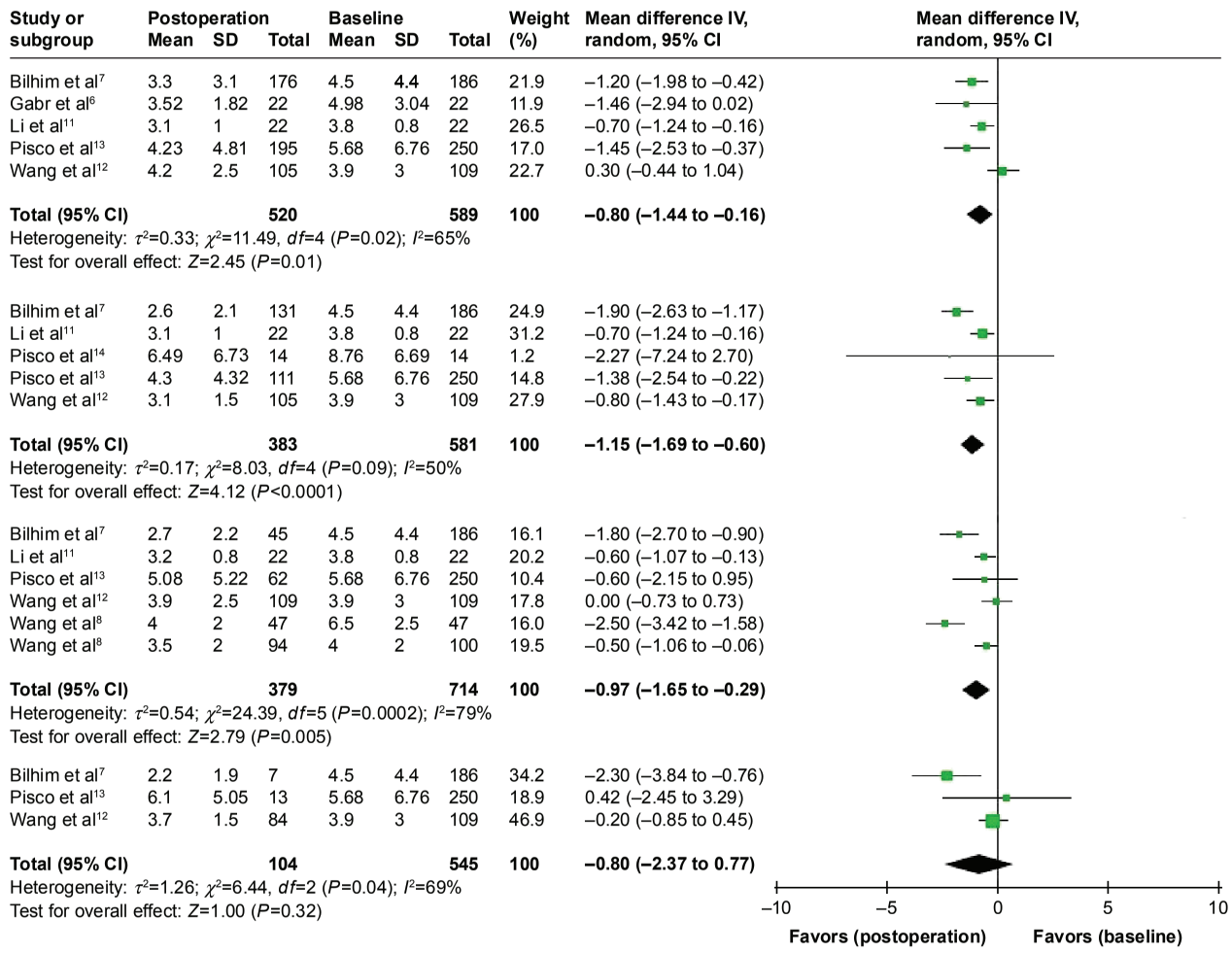

Figure 5 A forest plot about PSA changes after PAE at postoperative 1 month (**A**), 6 months (**B**), 12 months (**C**), and 24 months (**D**).
Abbreviations: CI, confidence interval; IV, intravenous; PAE, prostate artery embolization; PSA, prostate-specific antigen; SD, standard deviation.

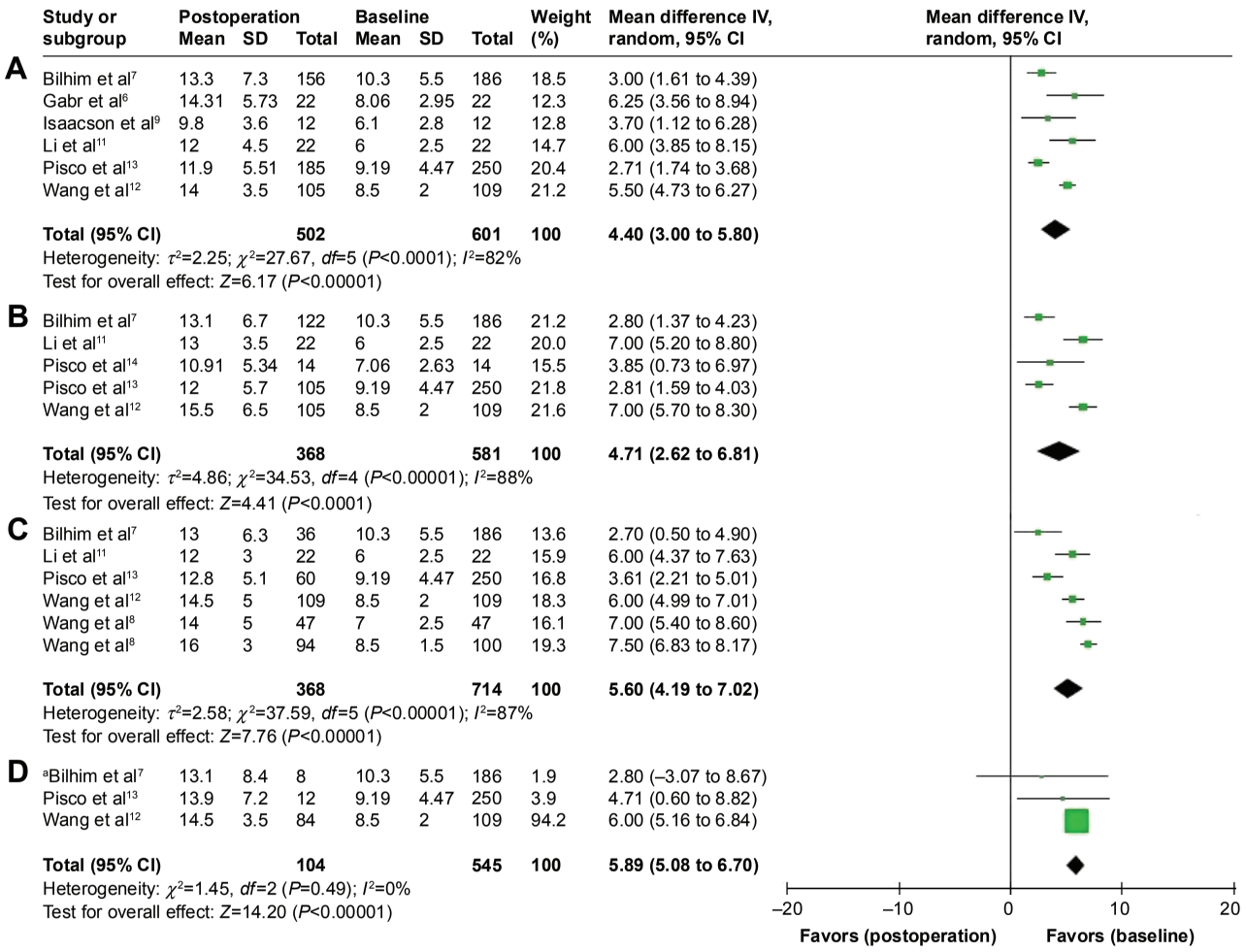

Figure 6 A forest plot about Q_{max} changes after PAE at postoperative 1 month (**A**), 6 months (**B**), 12 months (**C**), and 24 months (**D**).
Note: [a]Using the fixed-effects model.
Abbreviations: CI, confidence interval; IV, intravenous; PAE, prostate artery embolization; SD, standard deviation; Q_{max}, peak urinary flow rate.

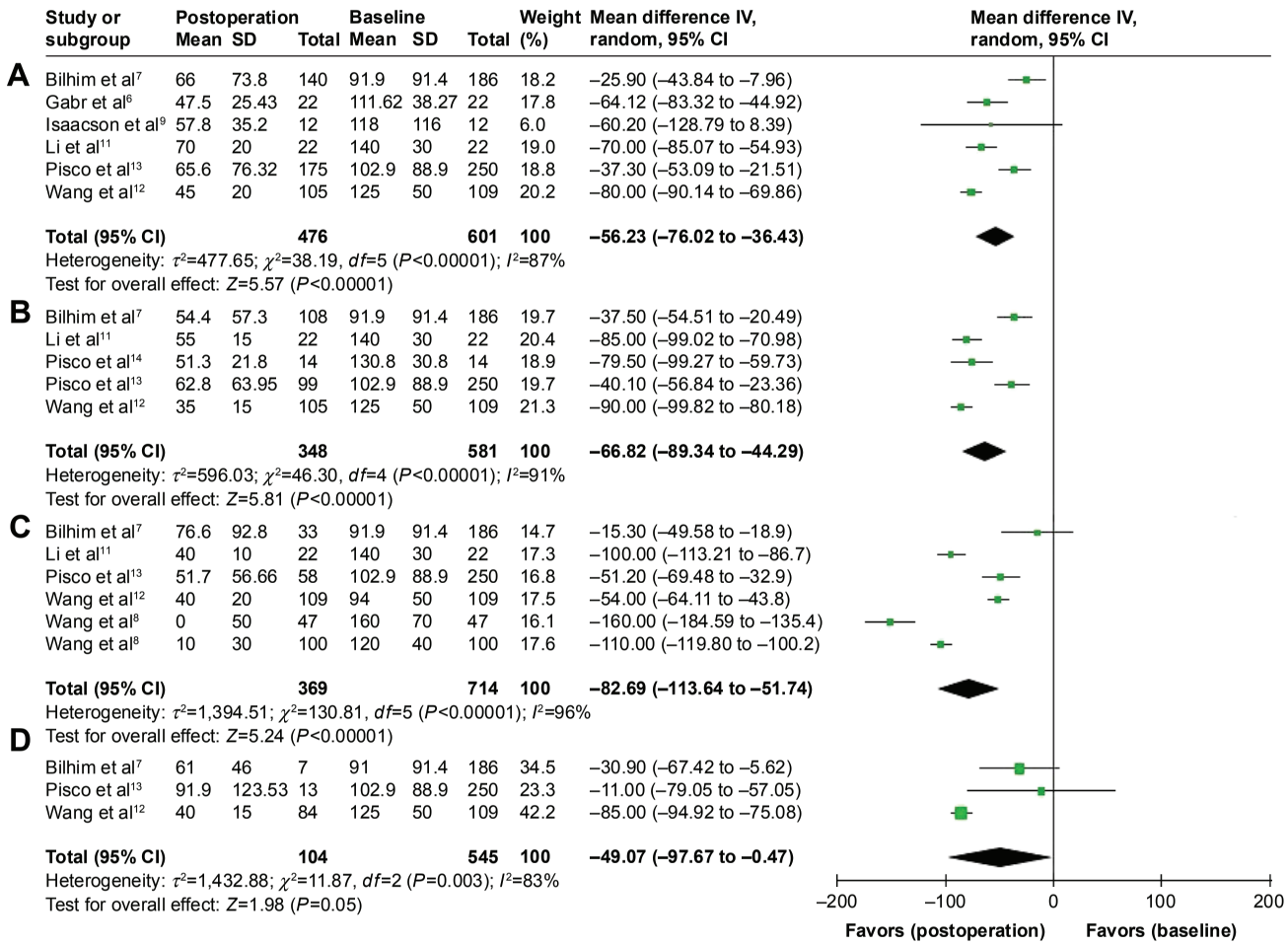

Figure 7 A forest plot about PVR volume changes after PAE at postoperative 1 month (**A**), 6 months (**B**), 12 months (**C**), and 24 months (**D**).
Abbreviations: CI, confidence interval; IV, intravenous; PAE, prostate artery embolization; PVR, postvoid residual; SD, standard deviation.

Compared with baseline, PVR volume had significant decreases at postoperative 1 month (WMD −56.23, 95% CI −76.02 to −36.34, $P<0.00001$), 6 months (WMD −66.82, 95% CI −89.34 to −44.29, $P<0.00001$), 12 months (WMD −82.69, 95% CI −113.64 to −51.74, $P<0.00001$) and 24 months (WMD −49.07, 95% CI −97.67 to −0.47, $P=0.05$).

IIEF-5 scores

Nine studies involving 609 participants, eight studies involving 463 participants, six studies involving 372 participants and three studies involving 102 participants included data representing IIEF-5 score changes at postoperative 1 month (Figure 8A), 6 months (Figure 8B), 12 months (Figure 8C) and 24 months (Figure 8D), respectively.

Compared with baseline, the IIEF-5 scores were slightly increased at postoperative 1 month (WMD 0.49, 95% CI −0.30–1.28), but the difference was not statistically significant ($P=0.23$). There were significant increases at postoperative 6 months (WMD 1.29, 95% CI 0.48–2.10, $P=0.002$) and 12 months (WMD 1.36, 95% CI 0.69–2.02, $P<0.0001$). However, a slight decrease turned up at postoperative 24 months (WMD −0.81, 95% CI −2.08–0.46), which was not statistically significant ($P=0.21$).

Changes after PAE on large volume (PV ≥80 mL) BPH

Four studies, involving 179 participants, included data representing changes in the large volume BPH (PV>80 mL).[9–12] All the results matched the earlier findings, except that PSA had no obvious decrease during the 3-month follow-up and that the IIEF-5 scores had no significant changes during the 12-month follow-up. The comparison of changes after

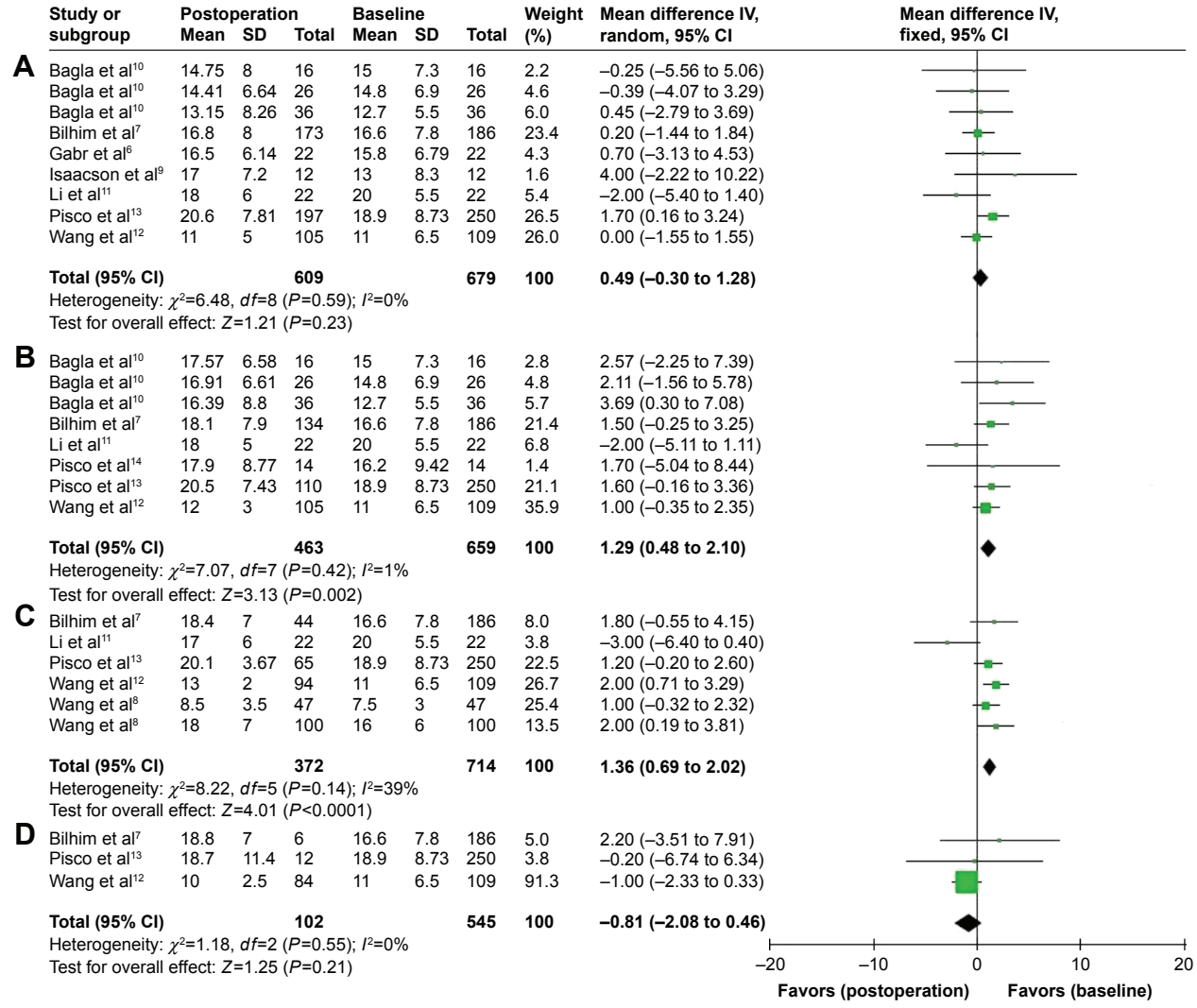

Figure 8 A forest plot about IIEF-5 score changes after PAE at postoperative 1 month (**A**), 6 months (**B**), 12 months (**C**), and 24 months (**D**).
Abbreviations: CI, confidence interval; IIEF-5, International Index of Erectile Function; IV, intravenous; PAE, prostate artery embolization; SD, standard deviation.

Table 2 Comparison of changes after PAE on large volume (PV ≥80 mL) BPH with baseline[9–12]

Variables	1 month		3 months		6 months		12 months	
	MD (95% CI)	***P*-value**	**MD (95% CI)**	***P*-value**	**MD (95% CI)**	***P*-value**	**MD (95% CI)**	***P*-value**
IPSSs	−15.97 (−17.25 to −14.68)	<0.00001	−17.97 (−19.00 to −16.94)	<0.00001	−18.61 (−19.74 to −17.48)	<0.00001	−18.32 (−19.54 to −17.09)	<0.00001
QoL scores	−2.51 (−2.74 to −2.29)	<0.00001	−2.64 (−3.30 to −1.98)	<0.00001	−2.45 (−3.10 to −1.80)	<0.00001	−2.50 (−2.83 to −2.17)	<0.00001
PV	−13.11 (−20.63 to −5.60)	0.0006	−43.39 (−49.92 to −36.85)	<0.00001	−47.05 (−53.50 to −40.60)	<0.00001	−47.58 (−53.94 to −41.21)	<0.00001
PSA	−0.23 (−1.21 to 0.74)	0.64	−0.45 (−1.41 to −0.52)	0.36	−0.74 (−1.15 to −0.33)	0.0004	−0.42 (−0.82 to −0.03)	0.04
Q_{max}	5.42 (4.73 to 6.12)	<0.00001	6.66 (5.9 to 7.43)	<0.00001	7.00 (5.95 to 8.05)	<0.00001	6.00 (5.14 to 6.86)	<0.00001
PVR volume	−76.64 (−84.98 to −68.29)	<0.00001	−82.73 (−91.10 to −74.36)	<0.00001	−88.35 (−96.39 to −80.31)	<0.00001	−76.80 (−121.87 to −31.72)	0.0008
IIEF-5 scores	−0.04 (−1.31 to 1.22)	0.95	−0.65 (−1.93 to 3.23)	0.62	0.85 (−1.70 to 3.41)	0.51	−0.24 (−5.12 to 4.63)	0.92

Note: Data from Isaacson et al,[9] Bagla et al,[10] Li et al,[11] and Wang et al.[12]
Abbreviations: BPH, benign prostatic hyperplasia; CI, confidence interval; IIEF-5, International Index of Erectile Function; IPSS, International Prostate Symptom Score; MD, mean difference; PAE, prostate artery embolization; PSA, prostate-specific antigen; PV, prostate volume; PVR, postvoid residual; Q_{max}, peak urinary flow rate; QoL, quality of life.

PAE on large volume (PV ≥80 mL) BPH with baseline is presented in Table 2.

Complications

There were no life-threatening complications. Only one serious adverse event was seen in the study by Pisco et al:[14] a case of a small area (1.5 cm^2) of bladder wall ischemia in the right side of the base without involvement of the urethra or urethral orifices. The area of ischemia at the bladder base was removed by surgery without further complications.

Burning sensation in urethra (87/840, 10.4%) during the procedure seemed to be the main complication. Hematuria occurred in 57/840 (6.8%) participants, hematospermia in 49/840 (5.8%), a small rectal bleeding in 38/840 (4.5%) and inguinal hematoma in 16/840 (1.9%). All these complications disappeared spontaneously without any treatment. In all, 21/840 (2.9%) participants developed urinary tract infection and all responded to suitable antibiotics. A total of 80/840 (9.5%) participants had acute urinary retention (AUR) at 1–3 days after PAE. For relief, a temporary bladder catheter was placed, and they were able to void spontaneously before discharge. There were no cases of sexual impotence or retrograde ejaculation. Complications reported in the eligible studies are presented in Table 3.

Discussion

PAE was first utilized in the 1970s to treat refractory bleeding following prostatic interventions as well as for intractable hematuria.[15] It demonstrated a successful reduction in PV without serious complications in human beings in 2010.[2] The rationale for PAE is that prostate ischemia leads to PV reduction and hence clinical improvement.[16]

In this meta-analysis, compared with baseline, there were significant improvements in the IPSSs (−12.74 points), QoL scores (−2.07 points), PV (−17.33 mL), PSA (−0.80 ng/mL), Q_{max} (+4.4 mL/s) and PVR volume (−56.23 mL) after PAE at postoperative 1 month. It implied that PAE could take effect quickly. Furthermore, the IPSSs (−15.62 points), QoL scores (−2.15 points), Q_{max} (+5.89 mL/s) and PVR volume (−49.07 mL) still had significant improvements during the 24-month follow-up, suggesting that PAE had good control of symptoms within 2 years.

For PV and PSA, significant decreases were found during the 12-month follow-up, but not at postoperative 24 months. We thought that the effect of PAE cannot be maintained in the long-term period. Besides prostate size increasing with

Table 3 Complications reported in the eligible studies

Studies	Sample size	Complications						
		Urethral burning	Urinary tract infection	Hematuria	Hematospermia	Rectal bleeding	AUR	Inguinal hematoma
Gabr et al[6]	22	15	0	0	0	0	0	0
Bilhim et al[7]	186	0	1	14	15	10	9	6
Wang et al[8]	47	10	0	6	4	4	16	3
Wang et al[8]	100	12	0	8	8	7	9	3
Isaacson et al[9]	12	0	1	1	1	0	1	0
Bagla et al[10]	78	0	1	0	0	0	0	1
Li et al[11]	22	8	0	3	2	3	7	0
Wang et al[12]	109	19	0	11	9	8	31	3
Pisco et al[13]	250	23	19	14	10	6	6	0
Pisco et al[14]	14	0	2	0	0	0	1	0
Total	840	87	24	57	49	38	80	16

Abbreviation: AUR, acute urinary retention.

age, revascularization of the prostatic arteries after PAE may play a role in prostate regrowth. Pisco et al[13] observed this kind of revascularization in their patients with second PAE. Interestingly, the IPSSs still had a significant decrease despite prostatic enlargement at postoperative 24 months. This may suggest that physical reduction of the obstructing tissue was not the only reason for the improvement in LUTS after PAE.

In terms of the IIEF-5 scores, there was no significant increase until 6 months after PAE. The epidemiological evidence had suggested a clear and clinically meaningful association between LUTS and sexual dysfunction that was independent of age and comorbidity.[17] Along with the continuous improvement in LUTS, the IIEF-5 scores started to increase.

In addition, patients with large volume (PV ≥80 mL) BPH are often elderly and may have severe comorbidities. They have increased operative risk of undergoing TURP/open surgery or refuse any surgical treatment.[18] In this meta-analysis, for large volume (PV ≥80 mL) BPH, there were significant improvements in the IPSSs (−18.32 points), QoL scores (−2.50 points), PV (−47.58 mL), Q_{max}(+6.00 mL/s) and PVR volume (−76.80 mL) after PAE during the 12-month follow-up, and there were no life-threatening complications. PAE does offer the ability to treat BPH in these patients, due to its minimally invasive nature with low morbidity and the possibility to use local anesthetic without sedation.[8]

Subsequent studies have further compared the clinical outcome of PAE versus TURP. Carnevale et al[19] reported that both groups experienced significant improvement in IPSS, QoL, PV, and Q_{max} during the 12-month follow-up. TURP resulted in significantly higher Q_{max} and smaller PV than PAE but required spinal anesthesia and hospitalization, while IIEF scores were significantly higher in the PAE group. Gao et al[20] reported a similar result during the 24-month follow-up, except that the PAE group showed more complications, mostly related to AUR (25.9%), postembolization syndrome (11.1%) and treatment failures (5.3% technical; 9.4% clinical).

Nevertheless, there are some limitations to our analysis. The major limitations include heterogeneity in the participants chosen, different materials and sizes of embolic agents and bilateral or unilateral embolization. The subgroup and sensitivity analysis or a random-effects model might reduce these limitations, but cannot eliminate. Additionally, the sample sizes of some included studies were small, and there was no long-term follow-up study. Data in the studies covered by this meta-analysis are insufficient to determine whether or not PAE is as good as TURP. Stratified trials with high volume and long follow-up time are awaited to strengthen the evidence and to update our findings.

PAE is an effective, safe and well-tolerable treatment for LUTS related to BPH, including large volume (PV ≥80 mL) BPH, with good short-term follow-up. Studies with large number of cases and longer follow-up time are needed to validate our results.

Disclosure

The authors report no conflicts of interest in this work.

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