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ORIGINAL ARTICLE

Effect of urodynamic preoperative detrusor overactivity on the outcomes of transurethral surgery in patients with male bladder outlet obstruction: a systematic review and meta-analysis

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Abstract

Objective To investigate the effect of urodynamic detrusor overactivity (DO) on the outcomes of transurethral surgery in patients with male bladder outlet obstruction (BOO).

Materials and methods We systematically searched the PubMed, Embase, and Cochrane Library databases for articles published between January 1989 and June 2017. All results of eligible studies were synthesized.

Results Nine articles met the eligibility criteria. These studies included a total of 932 patients with a median number of 92 patients per study (range 40–190). Of the nine studies, the conventional transurethral prostatectomy was adopted in four studies, photoselective vaporization of prostate in three studies, and other surgical modalities in two studies. In patients with DO positive, the pooled mean difference (MD) was not significant for a better or poorer improvement in the International Prostate Symptom Score [pooled MD, −0.27; 95% confidence interval (CI), −1.75 to 1.22; studies, 9; participants, 827], quality-of-life score (pooled MD, −0.14; 95% CI, −0.46 to 0.18; studies, 7; participants, 734), maximal flow rate (pooled MD, 0.79; 95% CI, −1.57 to 3.14; studies, 8; participants, 781), and post-void residual volume (pooled MD, 2.81; 95% CI, −4.70 to 10.32; studies, 6; participants, 509) compared to patients with DO negative. Some comparisons showed between-study heterogeneity despite the strict criteria of the eligible studies. However, there was no clear evidence of publication bias in the funnel plots.

Conclusions Our meta-analysis results demonstrated that preoperative urodynamic DO has no diagnostic role in the prediction of surgical outcomes in patients with male BOO.

Keywords Benign prostatic hyperplasia · Bladder outlet obstruction · Transurethral surgery · Treatment outcome · Urodynamic study · Detrusor overactivity

Introduction

Detrusor overactivity (DO) is defined as a urodynamic observation characterized by involuntary detrusor contraction (IDC) during the filling phase of the urodynamic study (UDS) [1]. These DO findings are known to be highly correlated with benign prostatic hyperplasia (BPH) [2, 3]. Oelke et al. reported that DO was present in 61% of male patients with lower urinary tract symptom (LUTS) attributed to BPH. They also reported that DO was independently correlated with the degree of male bladder outlet obstruction (BOO) and age [2]. Oh et al. reported that DO was frequently observed in patients with male BOO than in those without (44.1 vs. 10.3%; $p=0.001$) [3]. Therefore, it can be deduced that the underlying DO may also be attributed to LUTS in patients with male BOO.

Traditionally, the primary goal of transurethral surgery in BPH is to lessen the bothersome LUTS caused by the prostatic enlargement [4, 5]. The mechanism for surgery is based on the classic male BOO model. There have been some controversies about whether transurethral surgery resolves urodynamic DO [6, 7]. van Venrooij et al. reported that DO was resolved in approximately

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50% of patients after transurethral prostatectomy (TURP) [6]. Conversely, another study reported that DO was not improved after the surgery in a long-term UDS follow-up (preoperative vs. follow-up, 40 vs. 64%, $p < 0.001$) [7]. If DO still remained after the surgery, then the symptom improvement might not be satisfactory, because the remaining irritation symptoms could be more prominent in those patients.

Surgery is the most invasive option for the treatment of male BOO, and causes irreversible functional and anatomical changes. To maximize the treatment effect and minimize the expected complications, appropriate selection of the surgical indication is crucial. However, it is remains unknown whether preoperative DO is a significant predictor of surgical outcomes in patients with male BOO [4, 5]. The recent international guidelines also could not confirm the recommendation statements in those specific situations owing to a lack of evidence [4, 5], because there have been no randomized studies about the usefulness of preoperative UDS for guiding clinical decisions in male BOO [4]. Moreover, a systematic review on this issue has never been performed.

Accordingly, to assemble the results of previously published studies, to provide reasonable clinical evidences is urgently necessary at present. Therefore, we conducted a systematic review and meta-analysis investigating the effect of preoperative DO on the outcomes of transurethral surgery in patients with male BOO.

Materials and methods

Search strategy

For this systematic review and meta-analysis, we followed the recent MOOSE and PRISMA recommendations [8, 9]. Entire processes were conducted according to the preformed study protocol. The current study was derived from a large study project entitled "Diagnostic value of UDS for male BOO patients who are considering transurethral surgery (Grant no. 23-2015-0050 from the Seoul National University Hospital Research Fund, Seoul, Republic of Korea)". Two other studies derived from that study project were recently published [10, 11]. Details of the search strategy were already mentioned in our previous studies [10, 11]. Our search strategy fully covered the terms related to UDS (including "urodynamic", "cystometry", or "pressure flow study"), BOO ("benign prostatic hyperplasia", "benign prostatic obstruction", or "male LUTS"), and transurethral surgery ("transurethral resection", "vaporization", "ablation", or "enucleation"). The last article search was done at June 2017 via the PubMed, Embase, and Cochrane Library databases. A complementary manual search was also performed.

Selection criteria of eligible studies

The inclusion criteria were as described in the previous studies [10, 11]. Briefly, original English-written articles (1) covering transurethral surgery of male BOO, (2) with preoperative patients groups according to the clear standards of urodynamic DO, (3) with outcome compartment according to the presence or absence of DO, and (4) with available data for study synthesis were selected as eligible studies. When duplications of study populations were suspected, the most recent or most informative article was chosen. Because randomized prospective studies on the investigated issues are rare, we did not set a limit on the study design. The entire processes of abstract screening and full-text assessment were conducted by three independent reviewers (MK, CWJ, and SJO). All disagreements among reviewers were discussed at a consensus meeting.

Data collection and meta-analysis

The overall characteristics of eligible studies including study design, population size, type of surgery, urodynamic definition of DO, and Methodological Index for Non-Randomized Studies (MINORS) score [12] (Table 1), and the population characteristics including age, time of outcome assessment, and compared outcome parameters (Table 2) were retrieved form the each eligible article. Improvements in the International Prostate symptom score (ΔIPSS), quality-of-life score (ΔIPSS-QoL), maximal flow rate (ΔQ_{max}), and post-void residual volume (ΔPVR) were compared between patients with and without preoperative DO. For the comparisons, pooled mean differences (MDs) were used as summarizing statistics for meta-analysis. The pooled MD of > 0 indicated that the preoperative DO-positive patients had better treatment outcomes than the preoperative DO-negative patients. To calculate pooled MDs, the mean and standard deviation (SD) values of each arm were needed. When these values were unavailable, previously suggested methods [13] were used to estimate the necessary values. The details are shown in Appendix 1. A random-effects model was adopted for a conservative conclusion. A p value of < 0.05 without overlapping the zero of the 95% confidence interval (CI) was considered significant.

Reliability assessment

The quality of included studies was assessed using the MINORS score [12]. The MINORS score consists of followings 12 items with each score range 0–2: aim of the study, inclusion of consecutive patients, prospective collection of data, endpoint appropriate to the study aim, unbiased

Table 1 Main characteristics of the eligible studies

Study	Year	Country	Recruitment period	Study design	Level of evidence	Total study population	Type of surgery	Standards of DO	Cutoff	Quality assessment (0–24)*
Machino [17]	2002	Japan	1992–1999	Retrospective	3	62	TURP	IDC	≥ 15-cmH_2O	14
Monoski [18]	2006	USA	2002–2004	Retrospective	3	40	PVP	IDC	Positive	14
Seki [19]	2006	Japan	1993–2001	Retrospective	3	190	TURP	IDC	Positive	14
Tanaka [20]	2006	Japan	1995–1997	Retrospective	3	92	TURP	IDC	Positive	18
Paick [21]	2007	Korea	NA	Retrospective	3	68	PVP	IDC	Positive	15
Cho [22]	2010	Korea	2006–2007	Retrospective	3	149	PVP	IDC	Positive	15
Masumori [23]	2010	Japan	1995–1997	Retrospective	3	92	TURP	IDC	Positive	14
Ryoo [24]	2015	Korea	2009–2013	Retrospective	3	174	HoLEP	IDC	Positive	18
Suh [25]	2017	Korea	2005–2015	Retrospective	3	65	TUIP	IDC	Positive	19

DO detrusor overactivity, *TURP* transurethral prostatectomy, *IDC* involuntary detrusor contraction, *PVP* photoselective vaporization of the prostate, *NA* not available, *HoLEP* Holmium laser enucleation of the prostate, *TUIP* transurethral incision of the prostate

*Evaluated using Methodological Index for Non-Randomized Studies (MINORS) [12]

evaluation of endpoints, follow-up period appropriate to the major endpoint, loss to follow-up not exceeding 5%, a control group having the gold standard intervention, contemporary groups, baseline equivalence of groups, prospective calculation of the sample size, and statistical analyses to the study design [12]. Subgroup analysis was performed on type of surgery and the definition of urodynamic DO to evaluate the effects of type of surgical intervention and DO diagnostic criteria. Heterogeneity chi-squared test (Cochran's Q test) [14] and I^2 statistics (Higgin's H test) [15] were applied to evaluate the inter-study heterogeneity. Possibilities of publication bias were evaluated using funnel plots (Harbord test) [16]. Review Manager (RevMan) version 5.3 (The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark) was used for data synthesis.

Results

Our search strategy found a total of 4611 articles (PubMed, 1675 articles; Embase, 2373 articles; Cochrane Library database, 381 articles; hand search, 182 articles). Among them, 1676 articles were excluded because of duplication and 2653 were excluded based on abstract screening. Full-text assessments were performed on the remaining 282 articles, and we excluded 273 articles for different reasons (Fig. 1). Finally, nine studies were chosen as eligible studies [17–25].

General characteristics of eligible studies

The nine eligible studies included a total of 932 patients, with a median number of 92 patients per study (range 40–190). All articles were retrospective studies. Four of seven articles used TURP as surgical modality [17, 19, 20, 23], three studies used photoselective vaporization of prostate [18, 21, 22], and one study each adopted holmium laser enucleation of the prostate (HoLEP) [24] and transurethral incision of the prostate [25]. The definition of urodynamic DO was similar in all articles (i.e., any amplitude of IDC during filling cystometry) [18–23], except for one study that defined as IDC ≥ 15 cmH_2O [17]. The median MINORS score of each study was 15 (range 14–18) without a significant correlation with population size ($p = 0.880$, by Spearman's correlation analysis; Table 1). The median or mean ages of study populations are presented in Table 2. The time of outcome assessment were varied from 1 to 144 months (Table 2).

DO positive vs. DO negative

Forrest plots comparing the treatment outcomes between urodynamic DO-positive and DO-negative patients are shown in Fig. 2. Each figure represents the pooled

Table 2 Patient characteristics

Study	No. of analyzed patients	Median age, range (or ± SD) (years)	Type of surgery	Time of outcome evaluation (months)	Compared outcome parameters			
					Symptom score	QoL score	Q_{max} (mL/s)	PVR (mL)
Machino [17]	62	70.3 (mean), (± 5.4)	TURP	3	IPSS	IPSS-QoL	Available	Available
Monoski [18]	25	NA	PVP	1, 3, 6, 12	IPSS	NA	Available	Available
Seki [19]	190	71.3 (mean), (± 7.1)	TURP	3, 12	IPSS	IPSS-QoL	Available	NA
Tanaka [20]	92	69.7 (mean), 54–87	TURP	3	IPSS	IPSS-QoL	Available	Available
Paick [21]	68	68.5, 53–86	PVP	6–21, 9 (median)	IPSS	NA	Available	NA
Cho [22]	149	66, 62–71 (IQR)	PVP	1, 3, 6, 12	IPSS	IPSS-QoL	Available	Available
Masumori [23]	34	NA	TURP	3, 36, 84, 144	IPSS	IPSS-QoL	NA	NA
Ryoo [24]	174	69.3 (mean), 52–88	HoLEP	6	IPSS	IPSS-QoL	Available	Available
Suh [25]	40	60.9 (mean), 37–84	TUIP	3, 36.6 (median)	IPSS	IPSS-QoL	Available	Available

SD standard deviation, *QoL* quality of life, Q_{max} maximal flow rate on uroflowmetry, *PVR* post-void residual, *TURP* transurethral prostatectomy, *IPSS* International Prostate Symptom Score, *NA* not available, *PVP* photoselective vaporization of the prostate, *IQR* interquartile range, *HoLEP* Holmium laser enucleation of the prostate, *TUIP* transurethral incision of the prostate

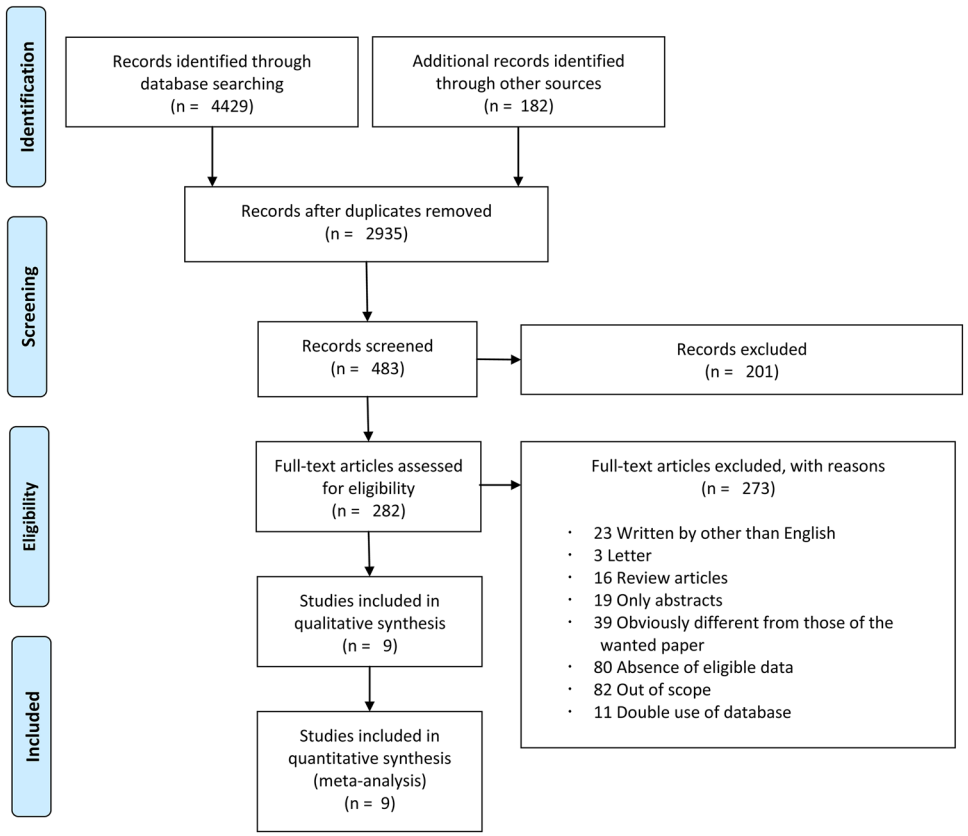

Fig. 1 Methodological flowchart of the systematic review

MD of ΔIPSS (Fig. 2a), ΔIPSS-QoL (Fig. 2b), ΔQ_{max} (Fig. 2c), and ΔPVR (Fig. 2d). In comparisons, the 95% CI of pooled MD overlapped with zero in all outcome parameters as follows: ΔIPSS (pooled MD, − 0.27; 95% CI, − 1.75 to 1.22; studies, 9; participants, 807; Fig. 2a), ΔIPSS-QoL (pooled MD, − 0.14; 95% CI, − 0.46 to 0.18; studies, 7; participants, 734; Fig. 2b), ΔQ_{max} (pooled MD, 0.79; 95% CI, − 1.57 to 3.14; studies, 8; participants, 781;

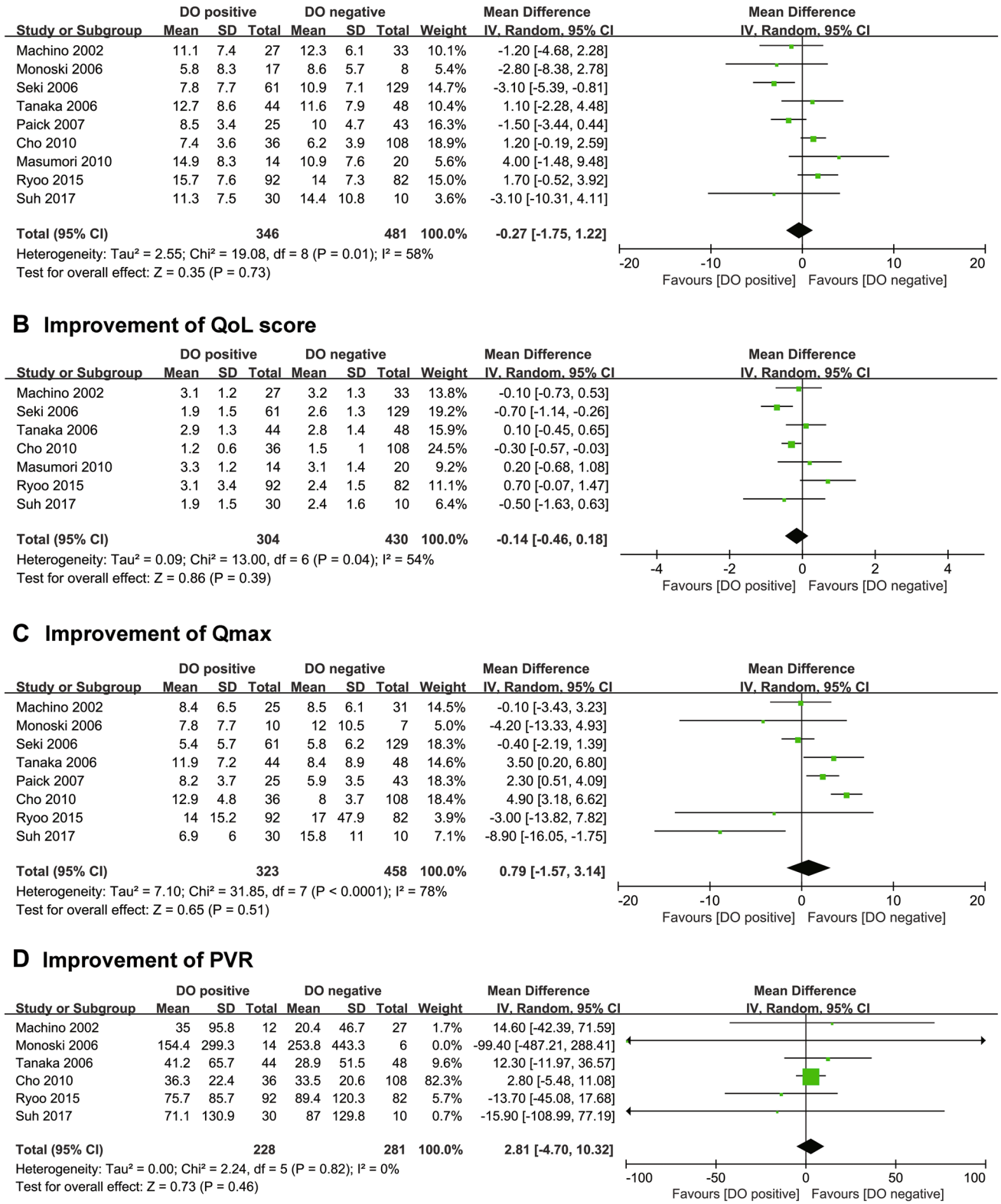

Fig. 2 Forest plots comparing improvements in the outcome parameters after transurethral surgery with or without detrusor overactivity (DO) using a random-effects model: **a** International Prostate Symptom Score (IPSS); **b** quality-of-life (QoL) score; **c** maximal flow rate (Q_{max}); **d** post-void residual volume (PVR)

Fig. 2c), and ΔPVR (pooled MD, 2.81; 95% CI, −4.70 to 10.32; studies, 6; participants, 509; Fig. 2d). This means that DO-positive and DO-negative patients with male BOO demonstrated no statistical difference in surgical outcomes after transurethral surgery.

Subgroup analysis according to surgery type and definition of DO

Subsequent subgroup analyses concerning the type of surgery and the definition of urodynamic DO were performed (Table 3). With the studies that adopted conventional TURP, all 95% CIs of pooled MDs overlapped with zero. This means that preoperative urodynamic DO did not cause the different surgical outcomes in the conventional TURP. In the subgroup analysis of studies that defined DO as any amplitude of IDC on filling cystometry, all 95% CIs of pooled MDs crossed the zero (Table 3). Therefore, it can be deduced that the differences in surgical outcomes between DO-positive and DO-negative subgroups are constantly insignificant regardless of the surgery type or DO definition.

Results of reliability assessments

Despite the strict criteria for the selection of eligible studies, heterogeneities among studies were still present (heterogeneity chi-squared test: $p < 0.05$ in comparisons of ΔIPSS, ΔIPSS-QoL, and ΔQ_{max}, I^2 range: 54–78%; Fig. 2). However, there was no clear evidence of funnel plot asymmetry for outcomes (Fig. 3). Therefore, it can be concluded that there was no clear evidence of publication bias.

Discussion

Diagnostic role of UDS in the preoperative evaluation of patients with BPH

The purpose of UDS is to reproduce and record the voiding symptoms to determine the underlying pathophysiology [26]. Because UDS is the only gold standard for the clinical assessment of male BOO [1], this diagnostic tool can be expected to be helpful in stratifying patients with BPH for surgical indications. However, the cost and potential morbidity of UDS limit its clinical use [27]. Accordingly, updated international guidelines recommend performing preoperative UDS for limited purposes such as ruling out other underlying pathophysiologies of LUTS [4, 5]. However, clinical evidences supporting those recommendations are rare [4, 5]. The results of our previous meta-analysis revealed that preoperative urodynamic male BOO positivity is well correlated with a better improvement of all outcome parameters including IPSS, IPSS-QoL, Q_{max}, and PVR [10], and that positivity for preoperative detrusor underactivity is related to poorer improvement in some outcome parameters including IPSS and Q_{max} [11]. The results can provide some clinical evidences for the effectiveness of preoperative UDS for selecting proper patients for transurethral surgery.

Effects of preoperative urodynamic DO on surgical outcomes

Urodynamic DO is also an important issue for the selection of proper indicators for male BOO surgery. However, there are also relatively few available studies exploring the significance of preoperative DO in transurethral surgery, and some of them have controversial results [17–23]. Our synthesized

Table 3 Results of subgroup analysis

	No. of included articles	Included studies	No. of participants	Pooled MD (95% CI)	I^2 (%)	X^2 (p value)
Conventional TURP						
Improvement of IPSS	4	[17, 19, 20, 23]	376	−0.39 (−3.18 to 2.40)	62	7.89 (0.05)
Improvement of IPSS-QoL	4	[17, 19, 20, 23]	376	−0.19 (−0.64 to 0.26)	56	6.80 (0.08)
Improvement of Q_{max}	3	[17, 19, 20]	338	0.75 (−1.56 to 3.06)	53	4.25 (0.12)
Improvement of PVR	2	[17, 20]	131	12.65 (−9.68 to 34.98)	0	0.01 (0.94)
DO definition as any IDC positive						
Improvement of IPSS	8	[18–25]	767	−0.16 (−1.80 to 1.47)	62	18.62 (<0.01)
Improvement of IPSS-QoL	6	[19, 20, 22–25]	674	−0.14 (−0.51 to 0.24)	61	12.82 (0.03)
Improvement of Q_{max}	7	[18–22, 24, 25]	725	0.87 (−1.78 to 3.51)	80	30.27 (<0.01)
Improvement of PVR	5	[18, 20, 22, 24, 25]	470	2.60 (−4.98 to 10.18)	0	2.07 (0.72)

MD mean difference, *CI* confidence interval, *IPSS* International Prostate Symptom Score, *QoL* quality of life, Q_{max} maximal flow rate on uroflowmetry, *PVR* post-void residual, *DO* detrusor overactivity

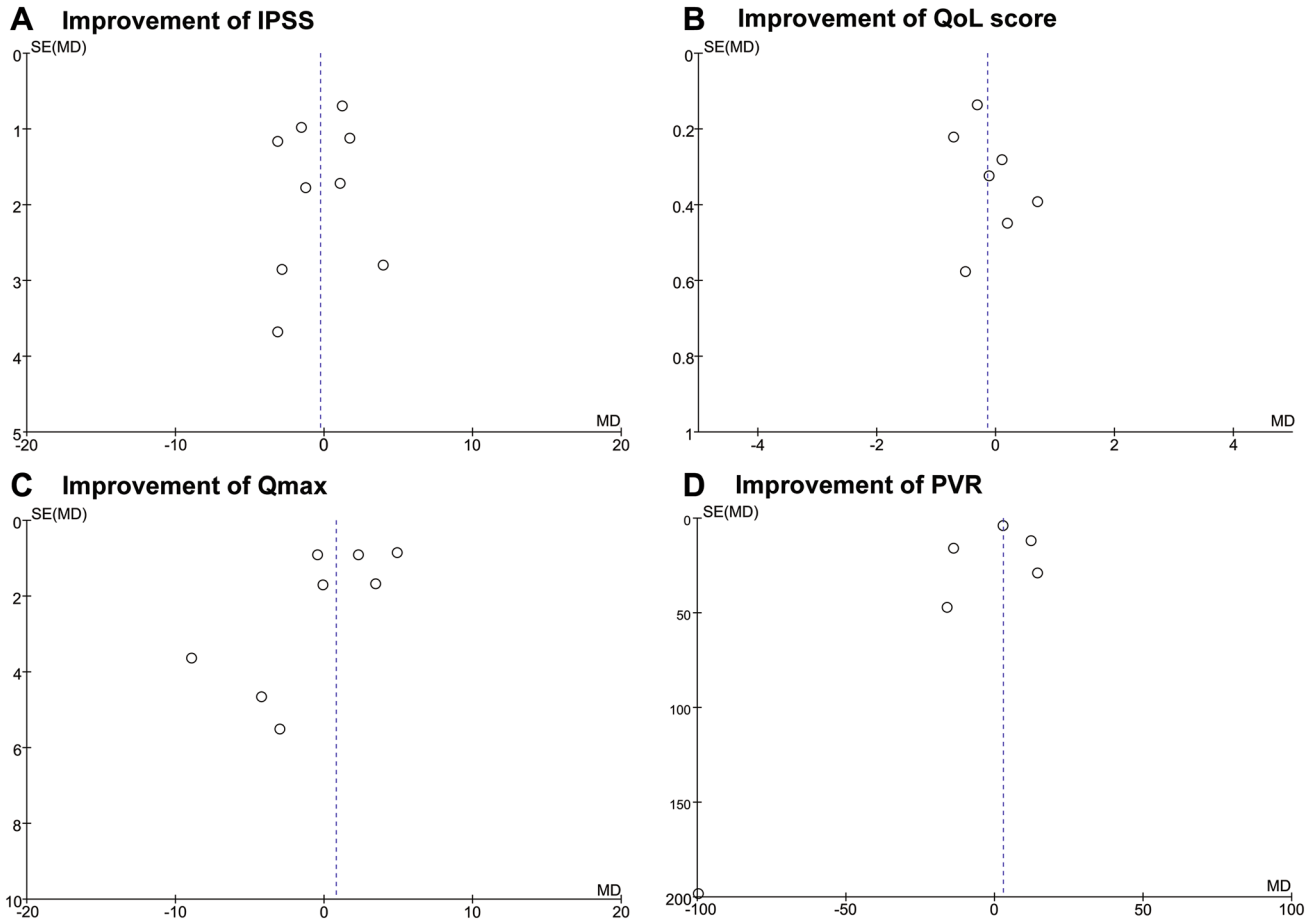

Fig. 3 Funnel graphs of the assessment of potential publication bias in studies comparing the improvements in outcome parameters after transurethral surgery with or without detrusor overactivity (DO): **a** International Prostate Symptom Score (IPSS); **b** quality-of-life (QoL) score; **c** Maximal flow rate (Q_{max}); **d** post-void residual volume (PVR)

data demonstrated that urodynamic DO was not correlated with all postoperative outcome parameters (Fig. 2). To draw clear conclusions, prospective randomized-controlled trials on the value of preoperative UDS are urgently needed, as in other diseases [28]. Unfortunately, there has been no published randomized-controlled trial on male BOO as aforementioned [4]. In these situations, the results of the current study are important, because these may be the highest level evidences in existence.

Preoperative DO showed no correlation with the degrees of improvement in surgical outcomes (Fig. 2). Some factors can explain those findings. First, the DO findings in male patients with LUTS could have originated from various causes. Preoperative DO can imply the predisposing of the underlying overactive bladder (OAB) and their attribution to LUTS [29]. However, those DO findings also suggest the secondary accommodation of bladder steaming from severe male BOO [2, 3]. Therefore, male patients with LUTS who are urodynamic DO positive can be presumed to have an independently accompanying OAB or long-standing severe male BOO. If the preoperative DO findings of patients indirectly indicate the presence of severe male BOO, those patients can also be expected to have the better improvements in symptoms [10]. Furthermore, preoperatively existing OAB symptoms and urodynamic DO might be improved significantly after transurethral surgeries. We already reported that OAB symptoms and urodynamic DO improved significantly after HoLEP in short-term follow-up [29]. These findings suggest that bladder dysfunction secondary to male BOO can be relieved by surgical deobstruction. It can be postulated that those features of DO can be counterbalanced by the effect of residual OAB symptoms after the surgery.

Second, in addition to DO being a urodynamic diagnostic criterion, OAB is diagnosed based on the prevalence of urgency, usually with frequency and nocturia [1]. Therefore,

the terms OAB and DO are not interchangeable, because 21% of patients with urgency do not have urodynamic DO [30]. Moreover, Hyman et al. also reported that DO was positive in only 44% of male patients with urgency or frequency, and negative in ≥ 25% of patients with urge incontinence [31]. The discordances between urodynamic findings and actual symptoms can also be another reason for preoperative DO being a poor predictor of surgical outcomes in patients with male BOO.

Limitations of the our study

The limitations of the current study are similar to those of the previous studies regarding the diagnostic value of urodynamic BOO [10] and detrusor underactivity [11] for predicting treatment outcomes of transurethral surgery owing to the similarity in the study design [10, 11]. Briefly, these limitations are as follows: (1) not including randomized prospective studies for data synthesis, (2) estimation of mean improvements and their SDs when values are unavailable (see Appendix 1), and (3) the presence of some degree of inter-study heterogeneity despite the strict criteria for eligibility. Almost included studies did not definitely mention the indications for surgeries and applied surgical modalities were diverse. Considering that patients characteristics of included studies were heterogeneous (Table 2), those indications might be institution- or physician-dependent. These limitations are dependent on the previous studies [10, 11]. Moreover, it may also be a limitation that the type of surgery and definition of DO were heterogeneous among the included studies. However, the results of our subgroup analysis on studies that adopted conventional TURP and studies that defined DO as any amplitude of IDC consistently showed no correlation between preoperative DO and degrees of surgical improvements (Table 3). These results indirectly imply that our synthesized conclusions are reasonable regardless of co-factors.

Conclusions of the current study

In conclusion, the results of the current meta-analysis demonstrated that preoperative urodynamic DO was not correlated with the degrees of improvements in all outcome parameters including IPSS, IPSS-QoL, Q_{max}, and PVR. Therefore, preoperative urodynamic DO seemed to have no diagnostic role in predicting better or poorer treatment outcomes in transurethral surgery in male patients with LUTS. However, prospective controlled trials are needed to confirm our observations about the diagnostic value of preoperative DO for selecting proper patients for transurethral surgery UDS.

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Compliance with ethical standards

Conflict of interest This study was supported by Grant no. 23-2015-0050 from the Seoul National University Hospital Research Fund. The authors have declared that no competing interests exist.

Research involving human participants or animals This study did not involve human participants or animals.

Informed consent Not applicable.

Appendix 1

See Table 4.

Appendix 1 Related issues about processing of the outcome parameters for data synthesis

Study	Related matters	Data processing
Machino [17]	Presented pre- and post-TURP IPSS, IPSS-QoL, Q_{max}, and PVR with SD of each group	Estimated the mean ΔIPSS, ΔIPSS-QoL, ΔQ_{max}, and ΔPVR with their SDs by using pre- and post-TURP values [13]
Monoski [18]	Presented pre- and post-PVP IPSS, Q_{max}, and PVR with SD of each group Presented 1,3,6, and 12-month postoperative data	Estimated the mean Δ IPSS, ΔQ_{max}, and ΔPVR with their SDs using pre- and post-PVP values Utilized the 1-month postoperative data due to the largest population
Seki [19]	Presented pre- and post-TURP IPSS, IPSS-QoL, and Q_{max}, with SD of each group Presented 3- and 12-month postoperative data	Estimated the mean ΔIPSS, ΔIPSS-QoL, and ΔQ_{max} with their SDs using pre- and post-TURP values Utilized the 3-month postoperative data owing to the large population
Tanaka [20]	Presented pre- and post-PVP IPSS, IPSS-QoL, Q_{max}, and PVR with SD of each group	Estimated the mean ΔIPSS, ΔIPSS-QoL, ΔQ_{max}, and ΔPVR with their SDs by using pre- and post-TURP values
Paick [21]	ΔIPSS and ΔQ_{max} were presented as median values with IQR Pre- and post-PVP IPSS-QoL, and PVR of each group were presented as median with IQR	Mean and SD were estimated using the presented median and IQR [13] Estimated the mean ΔIPSS-QoL and ΔPVR with their SDs using pre- and post-PVP values
Cho [22]	ΔIPSS, ΔIPSS-QoL, ΔQ_{max}, and ΔPVR were presented as median values with IQR Presented 1-, 3-, 6-, and 12-month postoperative data	Mean and SD were estimated using presented median and IQR Utilized the 1-month postoperative data owing to having the largest population
Masumori [23]	Presented pre- and post-TURP IPSS, and IPSS-QoL with SD of each group Presented 3-, 36-, 72-, and 144-month postoperative data	Estimated the mean Δ IPSS and Δ IPSS-QoL with their SDs using pre- and post-TURP values Utilized the 3-month postoperative data owing to the large population

TURP transurethral prostatectomy, *IPSS* International Prostate Symptom Score, *QoL* quality of life, Q_{max} maximal flow rate on uroflowmetry, *PVR* post-void residual, *SD* standard deviation, *PVP* photoselective vaporization of the prostate, *IQR* interquartile range

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