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Meta-Analysis

Comparison of urethral-sparing versus non urethral-sparing techniques of robot-assisted simple prostatectomy: a systematic review and meta-analysis of sexual, functional, and surgical outcomes

Noka Yogahutama[1]*, Raden Danarto[2]

[1]An-Nur Surgical Hospital, Sleman, Daerah Istimewa, Yogyakarta, Indonesia
[2]Division of Urology, Department of Surgery, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia

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***Correspondence:**
Dr. Noka Yogahutama,
E-mail: Nokahutama@ymail.com

ABSTRACT

Simple prostatectomy (SP) with urethral preservation offers various benefits. Recent advancements in technology have made urethral-sparing robot-assisted simple prostatectomy (US-RASP) more feasible. This systematic review compares the efficacy of US-RASP to non-urethral-sparing robot-assisted simple prostatectomy (Non-US-RASP). A systematic literature search was conducted on PubMed, Scopus, ProQuest, Cochrane Library, and ScienceDirect, following PRISMA 2020 guidelines up to September 2024. Meta-analyses of sexual, functional, and surgical outcomes were performed using Review Manager version 5.4. The risk of bias was assessed with the Newcastle-Ottawa scale (NOS). Six observational studies involving 615 patients were included (332 US-RASP versus 283 non-US-RASP). US-RASP significantly improved sexual outcomes, with higher 6-month ejaculatory preservation (OR 31.77, 95% CI: 13.28 to 76.02, p<0.001) and a higher 12-month MSHQ-EjD SF score (MD 6.38, 95% CI: 5.90 to 6.85, p<0.001). Surgical outcomes favored US-RASP with shorter catheterization time (MD -2.67, 95% CI: -4.63 to -0.71, p=0.008) and reduced length of stay (MD -1.39, 95% CI: -2.51 to -0.28, p=0.01). However, US-RASP was associated with a higher 12-month PVR score (MD 14.00, 95% CI: 12.33 to 15.68, p<0.001). This meta-analysis suggests that US-RASP is an effective alternative to Non-US-RASP, demonstrating better sexual and surgical outcomes despite a higher PVR. However, these findings should be confirmed with a well-designed larger randomized trial.

Keywords: Prostatic hyperplasia, Simple prostatectomy, Urethral sparing, Urethra preservation, Robot surgical procedure

INTRODUCTION

Benign prostatic hyperplasia (BPH) is the most frequent disease in men of advanced age, leading to benign prostatic obstruction (BPO) and causing lower urinary tract symptoms (LUTS).[1,2] According to current guidelines, surgical treatment is indicated for patients with recurrent or refractory urinary retention, recurrent urinary tract infections (UTIs), bladder stones or diverticula, gross hematuria, renal insufficiency, or LUTS refractory to other therapies.[3,4] Currently, monopolar transurethral resection of the prostate (M-TURP) is the first-line treatment for BPH.[3,4] However, prostate size must be considered as a critical factor to determine the choice of surgical treatment. For large prostate glands (>80 ml), the surgical treatment options include simple prostatectomy (SP) and endoscopic enucleation of the prostate (EEP), such as holmium laser enucleation of the prostate (HoLEP), bipolar enucleation of the prostate (B-TUEP), and thulium laser enucleation of the prostate (ThuLEP).[3] Despite the advantages of EEP, SP can still be an effective option for large prostate glands due to its ability to remove a greater volume of prostate adenoma.[5,6]

Open simple prostatectomy (OSP) has been the gold standard for surgical treatment of large prostate glands for decades. However, a meta-analysis by Haibin et al reported that OSP is associated with greater blood loss, longer catheterization times, and longer hospital stays compared to its transurethral laser alternatives for large prostate glands.[7] Additionally, the standard OSP techniques, such as the Millin (transcapsular) and Freyer (transvesical) approaches, inevitably injure the urethra, ejaculatory duct, and bladder.[8,9] In response, the urethral-sparing technique, proposed by Dixon et al in 1990 and named the "Madigan" technique, has been associated with reduced perioperative morbidity, avoidance of continuous bladder irrigation (CBI), and preservation of ejaculatory function, making it more suitable for young, male, sexually active patients.[10] Despite its advantages, urethral-sparing technique has not been widely accepted due to the complexity of dissecting the thin prostatic urethra, particularly when it is adhered to the prostatic adenoma.[11] This technique would be harder in cases involving an enlarged median prostatic lobe, as well as the risk of unintentional urethral injury.[11]

Thanks to advancements in technology, minimally invasive alternatives of OSP, such as laparoscopic simple prostatectomy (LSP) and robot-assisted simple prostatectomy (RASP), have been introduced. Since the first RASP procedure described in 2008 by Sotelo et al, RASP has gained acceptance due to the steep learning curve and technical difficulties associated with LSP.[12] The potential benefits of RASP such as stereoscopic three-dimensional (3D) vision, greater degrees of freedom, and tremor suppression, also make the urethral-sparing technique more feasible, as first described by Simone et al and Wang et al studies.[13-15] To date, a variety of urethral-sparing techniques have been introduced using RASP technology.[14-17] However, there is still no consensus regarding the efficacy of urethral-sparing robot-assisted simple prostatectomy (US-RASP) compared to other techniques of RASP without urethral preservation (non-US-RASP).

Therefore, this study aims to conduct a systematic review and meta-analysis to compare the efficacy and safety between US-RASP and non-US-RASP in treating BPH.

METHODS

Search strategy and eligibility

This systematic review and meta-analysis was registered in the PROSPERO database (CRD42024595991). The present study followed the preferred reporting items for systematic reviews and meta-analyses 2020 (PRISMA 2020 Statement) until September 2024.[18] Since there were no randomized controlled trial (RCT) studies available during the literature search period, we included the prospective or retrospective cohort studies that compared US-RASP and non-US-RASP in patients diagnosed with BPH who were indicated for SP. We systematically searched for studies in 6 online databases, including PubMed, Scopus, ProQuest, Cochrane central register of controlled trials (CENTRAL), and ScienceDirect. Medical subject headings (MeSH) terms and keywords were used in the literature search.

Inclusion and exclusion criteria

The inclusion criteria for this systematic review were determined using the PICOS framework, which consists of population (P), intervention (I), comparison (C), outcome (O), and study design (S). According to this framework, the criteria were as follows: (P) patients diagnosed with BPH indicated for SP; (I) US-RASP techniques; (C) non-US-RASP techniques; (O) sexual outcomes, functional outcomes, and surgical outcomes; and (S) prospective or retrospective cohort studies. We excluded studies that were case reports, conference abstracts, reviews, meta-analyses, duplicate studies, editorials, or not available in English language. We included only studies that compared US-RASP and non-US-RASP and reported at least one of the outcomes required as mentioned in the PICOS framework.

Study selection

The literature search using keywords in databases was performed by one reviewer. The titles and abstracts of all included studies from the databases were screened independently by two reviewers. The full texts of the included studies were checked for inclusion and exclusion criteria. Any disagreements were discussed between the two reviewers and resolved through mutual consensus.

Data extraction and study quality

Data from the included studies were extracted by 2 reviewers and cross-checked using Microsoft Excel version 15.20 (Microsoft Corporation, Washington, USA, 2016). Several pieces of information were extracted, including the author, study origin, study period, study design, robotic tools, surgical approaches, surgical techniques, number of patients, mean or median age, and baseline values of the international index of erectile function-5 (IIEF-5), male sexual health questionnaire ejaculatory dysfunction short form (MSHQ-EjD SF), prostate volume, international prostate symptom score (IPSS), Q_{max}, post-void residual (PVR), and prostate-specific antigen (PSA). Information necessary for meta-analysis calculations was also extracted, including the 12-month postoperative values of IIEF-5, MSHQ-EjD SF, IPSS, Q_{max}, PVR, PSA, as well as the number of ejaculatory preservation cases, operative time, estimated blood loss (EBL), length of catheterization, length of stay, and number of postoperative complications based on the Clavien-Dindo classification. Since all the included studies were observational, the risk of bias was assessed using the Newcastle-Ottawa scale (NOS) by 2 reviewers, which consists of 8 questions across 3 categories: selection, comparability, and outcome. A star is given for

each question, except the comparability question, which has a maximum of 2 stars. The total number of stars represents the quality of the study and is classified as "low quality" (0-3 stars), "moderate quality" (4-6 stars), and "high quality" (7-9 stars). Any disagreements were discussed between the 2 reviewers and resolved through mutual consensus.

Statistical analysis

Meta-analyses were performed when two or more studies reported the same outcomes. For continuous data presented as medians and range values, we used the formulas with the Box-Cox method described by McGrath et al to transform the medians and range values into means and standard deviations (SD).[19] We also used the formula recommended by the Cochrane handbook for systematic reviews of interventions to combine continuous data between groups.[20] The odds ratio (OR) with the Mantel-Haenszel (MH) method was used to present dichotomous data, while the mean difference (MD) with the inverse variance (IV) method was used to present continuous data. All OR and MD results were presented with 95% confidence intervals (CI), and a p value (p) of less than 0.05 was considered statistically significant. Heterogeneity was described by the I^2 value and classified as low (<30%), moderate (30-60%), substantial (50-90%), and considerable (75-100%), according to the Cochrane handbook for systematic reviews of interventions.[20] A random-effects model was used when I^2 >50%, while a fixed-effects model was used when I^2 ≤50%. Funnel plots of statistically significant analyses were generated, with asymmetry indicating a potential publication bias. All meta-analyses of the included studies were performed using Review Manager (RevMan) version 5.4 software (The Cochrane Collaboration, United Kingdom, 2020).

RESULTS

Search result and study characteristics

The literature search was performed according to the 2020 PRISMA statement flow chart and retrieved 460 studies from 5 databases as shown in Figure 1. A total of 214 duplicates were removed, resulting in 246 studies screened based on the titles and abstracts and of which 180 irrelevant studies were excluded. There were 11 studies that could not be retrieved and the full text of 55 studies were screened. A total of 6 out of 55 studies were included, comprising 3 prospective non randomized cohort studies and 3 retrospective cohort studies, which involved 615 patients (332 US-RASP patients and 283 non-US-RASP patients). The baseline characteristics of the included studies are presented in Table 1. The US-RASP techniques included in this study consisted of a Madigan technique, while the non-US-RASP techniques used as a comparison in this study consisted of standard techniques of Freyer and Millin.

Risk of bias analysis and quality assessment

The risk of bias of included studies based on NOS were classified as "moderate quality" in 3 studies and "high quality" in the other 3 studies, the scores varied between 5 and 7 as shown in Table 2. All of the included studies were not achieved stars in assessment of outcome questions due to no statement of independent or blind assessment. This might be caused by the nature of surgical intervention which blindment of the study between surgeons and patients would be nearly impossible. Publication biases were assessed with funnel plots generated from meta-analysis with statistically significant results as shown in Figure 2. There were no asymmetries in all of the funnel plots indicating no publication bias was observed.

Sexual outcomes

The sexual outcomes meta-analysis showed statistically significant results in 6-month ejaculatory preservation with 2 included studies (OR 31.77, 95% CI: 13.28 to 76.02, p<0.001) and 12-month MSHQ-EjD SF with 3 included studies (MD 6.38, 95% CI: 5.90 to 6.85, p<0.001) favoring US-RASP compared to non-US-RASP.[16,17,21,24] There was moderate and low heterogeneity with I^2 of 42% and 0%, respectively. However, the meta-analysis of 12-month IIEF-5 with 4 included studies showed a slightly higher score in US-RASP compared to non-US-RASP (MD 1.85, 95% CI: -0.95 to 4.65, p=0.20).[16,17,21,23] There was a considerable heterogeneity observed (I^2 =91%).

Functional outcomes

The functional outcomes meta-analysis showed statistically significant results in 12-month PVR with 4 included studies, with US-RASP having a higher score of 12-month PVR (MD 14.00, 95% CI: 12.33 to 15.68, p<0.001).[17,21,23,24] The heterogeneity was considered as moderate (I^2 =45%). However, the functional outcomes meta-analysis showed no statistically significant results for 12-month of the IPSS, Q_{max}, and PSA. A slightly lower score of US-RASP was observed in 12-month IPSS with 5 included studies (MD -0.08, 95% CI: -0.44 to 0.28, p=0.67) and 12-month PSA with 2 included studies (MD -0.02, 95% CI: -0.12 to 0.08, p=0.72), with moderate and low heterogeneity (I^2 =31% and I^2 =0%), respectively.[16,17,21,23,24] There was a slightly higher score for US-RASP in 12-month Q_{max} with 4 included studies (MD 0.03, 95% CI: -1.29 to 1.36, p=0.96) compared to non-US-RASP, although not statistically significant. However, there was low heterogeneity (I^2 =0%).[17,21,23,24]

Surgical outcomes

There was a statistically significant shorter meta-analysis results of catheterization time with 5 included studies (MD -2.67, 95% CI: -4.63 to -0.71, p=0.008) and length of stay meta-analysis with 5 included studies (MD -1.39, 95% CI: -2.51 to -0.28, p=0.01) in US-RASP compared to non-US-RASP.[17,21-24]

Table 1: Baseline characteristics of studies included in the meta-analysis.

Study	Origin	Study period	Type	Surgical approac-hes	Techniques	Pati-ents (n)	Age (year)	IIEF-5	MSHQ-EjD SF	Prostate volume (ml)	IPSS	Qmax (ml/s)	PVR (ml)	PSA (ng/ml)
Bove et al 2020[16]	Italy	2011-2019	RC	US-RASP	Madigan	14	66 (61.75-69.25)*	20.5 (19.5-23)*	10.5 (9-15)*	85.5 (74.5-118.5)*	28 (24-31.25)*	NR	NR	NR
				Non-US-RASP	Millin	23	72 (66-75)*	18 (10-23)*	9 (3.5-13.5)*	90 (85-116)*	30 (27-34)*	NR	NR	NR
					Freyer	8	74 (63-81.25)*	18 (6.75-22.25)*	10 (8-14)*	104 (90.5-121.25)*	29 (22.75-34.5)*	NR	NR	NR
Porpiglia et al 2021[17]	Italy	2017-2019	PC	US-RASP	Madigan modification	92	67 (64.3-70.8)*	18 (12.3-20)*	9 (6-11)*	140 (119-171)*	20 (16-24.8)*	8 (6.25-11)*	150 (57.5-163)*	9.7 (6.00-16.6)*
				Non-US-RASP	Millin	92	68 (64-71)*	19 (10-22)*	10 (5-11)*	135 (108-170)*	21 (17-27)*	9 (6.80-10.80)*	150 (80-180)*	9.8 (5.75-15.96)*
Fiori et al 2022[21]	Italy	2017-2021	PC	US-RASP	Madigan (full urethral sparing)	81	67±5.5	18±7.75	11 (4-11)*	143±42	20±8.75	8±4.75	150±105	9.7±10.6
					Madigan (partial urethral sparing)	25	66±4.3	18±7	9 (6-10)*	138±37	19±6	7.9±3.77	145±130	9.6±8.9
				Non-US-RASP	Millin	18	68±6.4	19±8	10 (5-11)*	135±61	21±7.31	9±4	150±100	9.8±9.7
Choi et al 2023[22]	Korea	2018-2021	PC	US-RASP	Madigan	32	69.8±6.9	15.3±7.8	9.1±4.5	100.1±20.4	22.3±6.8	6.6±3.9	141.8±155.8	NR
				Non-US-RASP	Freyer	30	71.8±7.2	NR	NR	99.3±21.6	23.8±6.1	5.9±3.1	153.5±135.4	NR
Bove et al 2024[23]	Italy	NR	RC	US-RASP	Madigan	93	67 (63-71)*	20 (15-22)*	NR	100 (85-127)*	21 (20-24)*	8 (6-9)*	NR	10 (7-24)*
				Non-US-RASP	Freyer	65	72 (63-75)*	17 (9-20)*	NR	140 (110-160)*	24 (18-28)*	7 (5-9)*	NR	6 (4-12)*
Shin et al 2024[24]	Korea	2021-2022	RC	US-RASP	Madigan	20	64.5 (63.0-68.8)*	NR	11.0 (8.0-12.8)*	80 (70.8-106.3)*	20.0 (18.0-27.8)*	7.7 (4.2-10.4)*	35 (10.0-187.5)*	NR
				Non-US-RASP	Freyer	22	70.0 (66.0-75.0)*	NR	10.0 (5.0-11.0)*	88.5 (63.8-123.3)*	22.0 (12.8-28.0)*	8 (3-14)*	96.5 (42.5-280.0)*	NR

Table 2: Outcomes included in each study and NOS bias assessment of included studies.

Study	Outcomes included	Newcastle-Ottawa scale (NOS)				
		Selection	Compara-bility	Exposure	Total score	Quality
Bove et al 2020[16]	B, C, D, H, K, L	***		**	5	Moderate
Porpiglia et al 2020[17]	A, B, C, D, E, F, G, H, I, J, K, L	****	*	**	7	High
Fiori et al 2022[21]	B, C, D, E, F, G, H, I, J, K	****	*	**	7	High
Choi et al 2023[22]	H, I, J, K, L	****	*	*	6	Moderate
Bove et al 2024[23]	B, D, E, F, H, J, L	***	*	**	7	Moderate
Shin et al 2024[24]	A, D, E, F, H, I, J, K	****	*	**	7	High

A=6-month ejaculatory preservation, B=12-month IIEF-5, C=12-month MSHQ-EjD SF, D=12-month IPSS, E=12-month Qmax, F=12-month PVR, G=12-month PSA, H=operative time, I=blood loss, J=catheterization time, K=length of stay, L=Clavien-Dindo ≤1

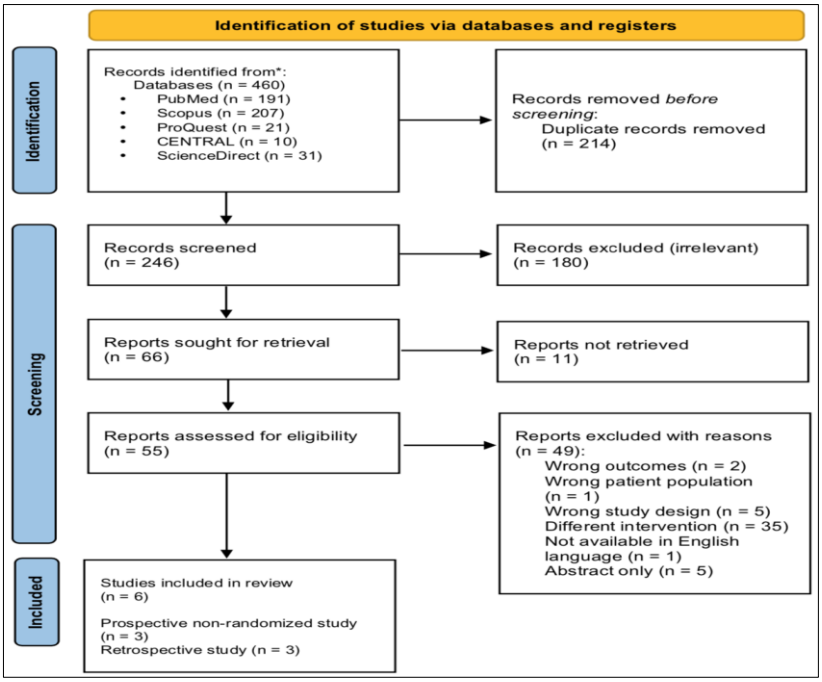

Figure 1: 2020 PRISMA statement flowchart.

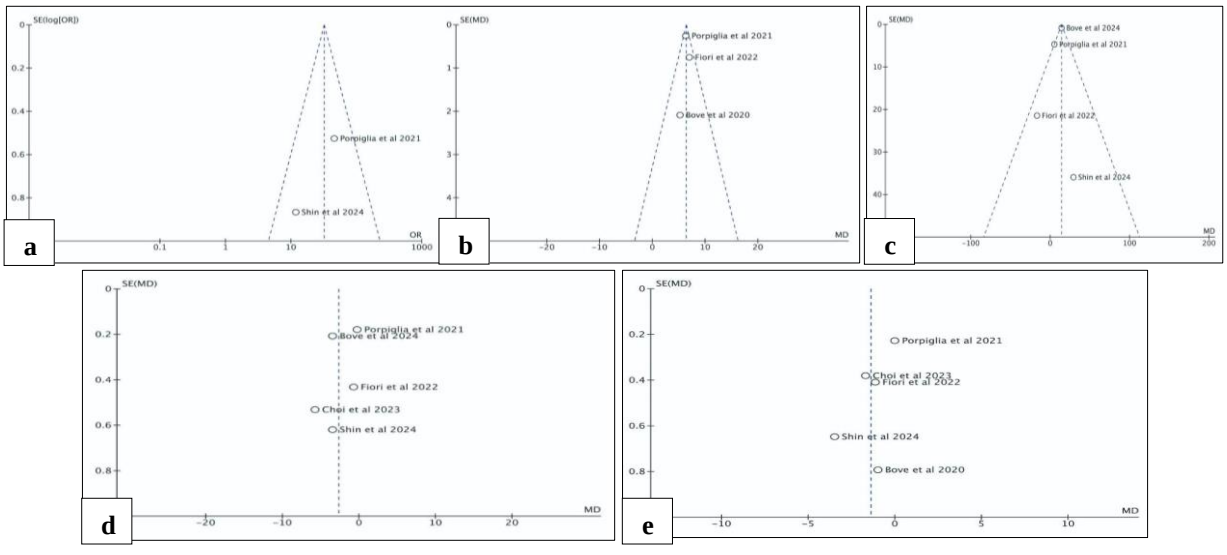

Figure 2: Funnel plots of statistically significant meta-analysis. (a) 6-month ejaculatory preservation, (b) MSHQ-EjD SF, (c) 12-month PVR, (d) catheterization time, and (e) length of stay.

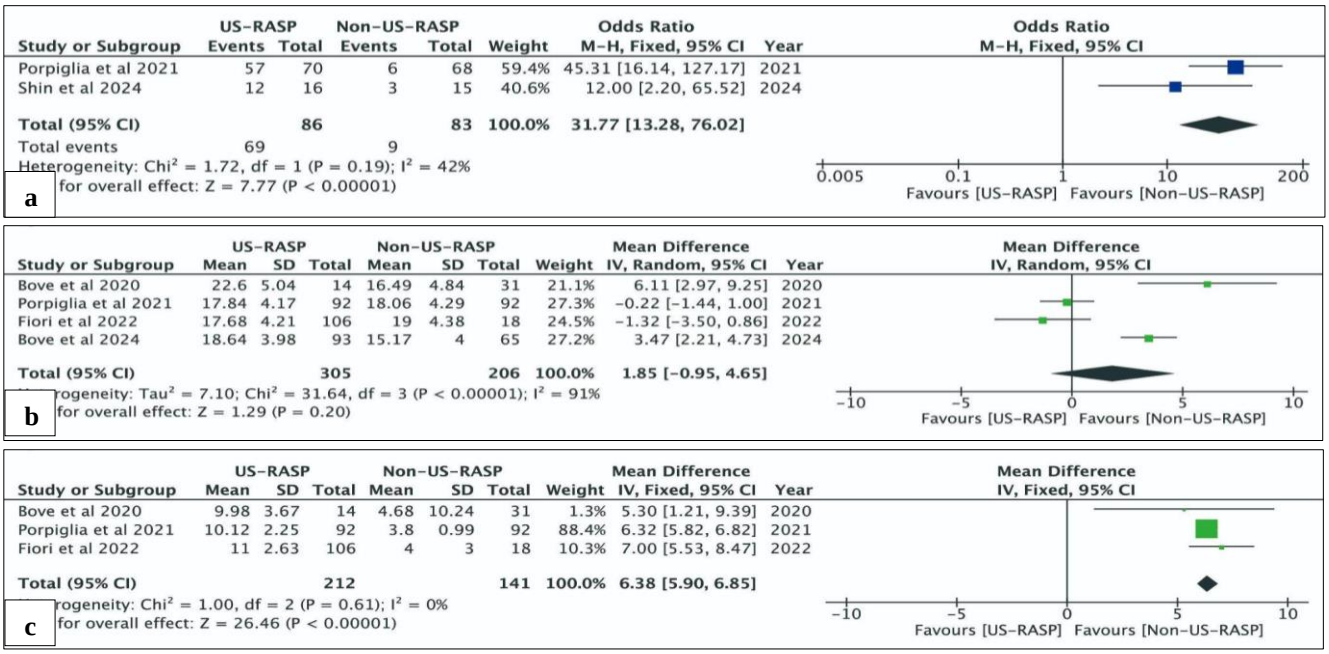

Figure 3: Forest plots of sexual outcomes with (a) 6-month ejaculatory preservation, (b) 12-month IIEF-5, and (c) 12-month MSHQ-EjD SF.

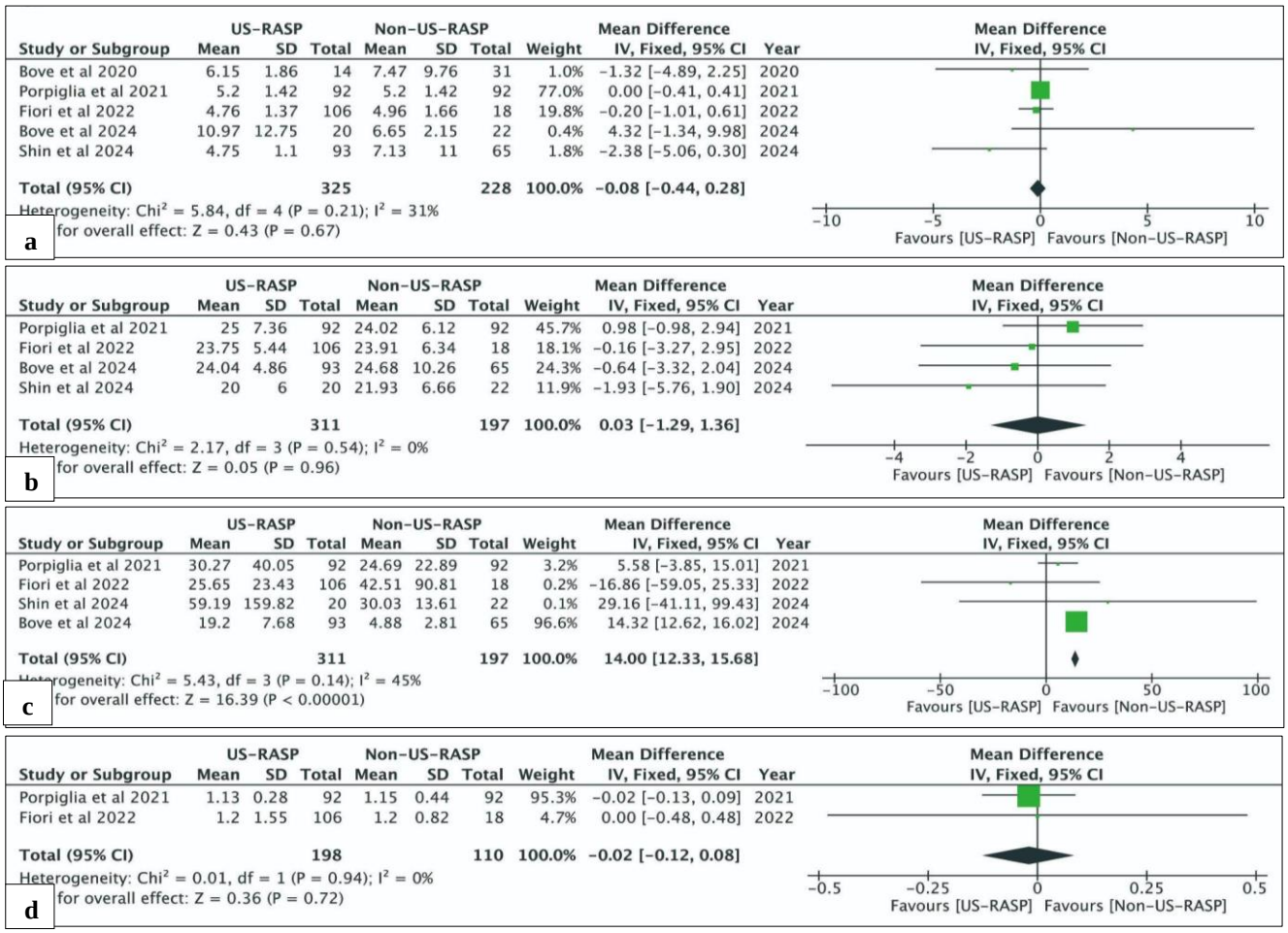

Figure 4: Forest plots of functional outcomes with (a) 12-month IPSS, (b) 12-month Qmax, (c) 12-month PVR, and (d) 12-month PSA.

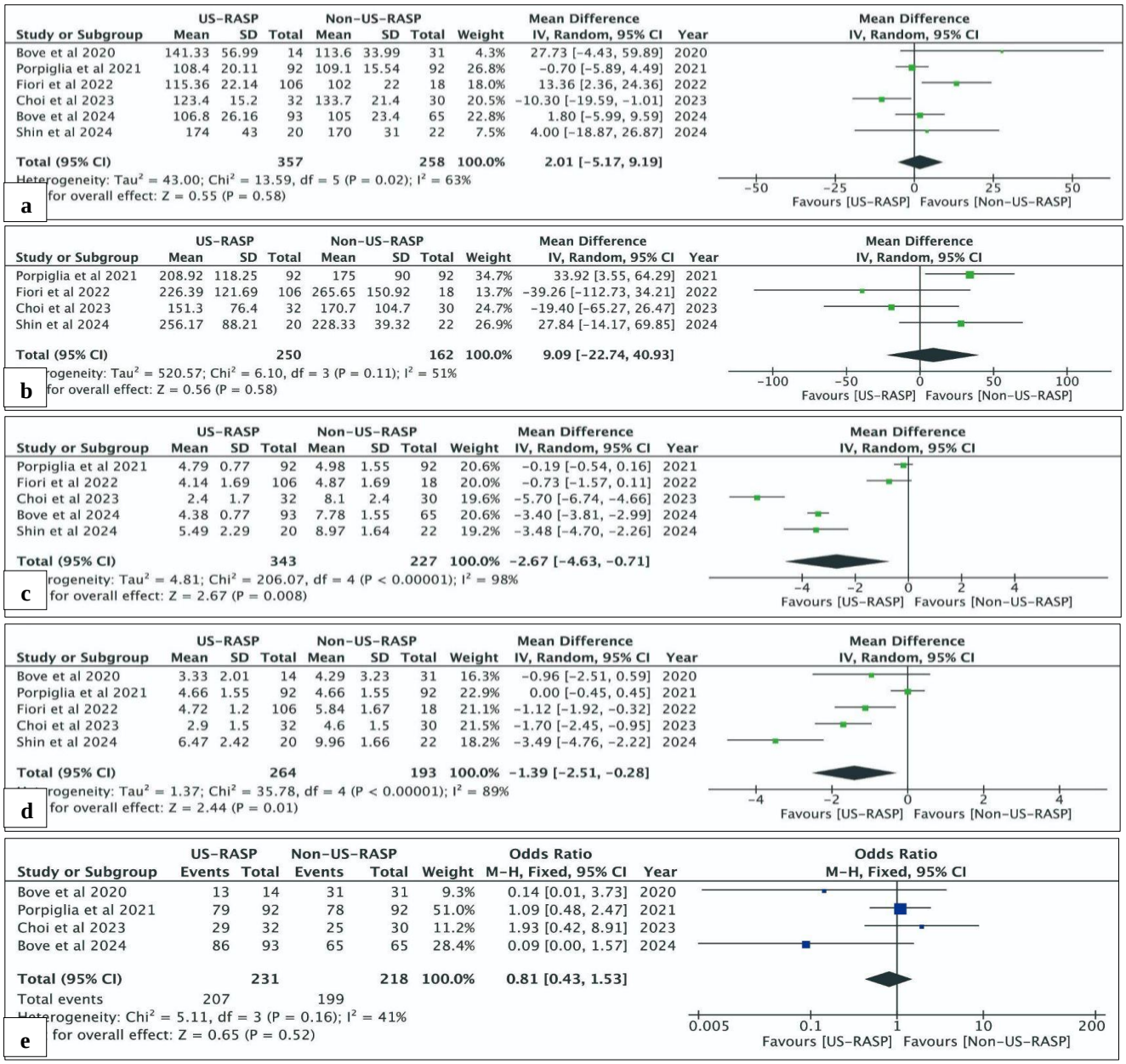

Figure 5: Forest plots of surgical outcomes with (a) operative time, (b) blood loss, (c) catheterization time, (d) length of stay, and (e) Clavien-Dindo ≤1.

However, there was considerable heterogeneity observed (I^2 =98% and I^2 =89%). The operative time meta-analysis with 6 included studies and blood loss meta-analysis with 4 included studies showed no statistically significant results, with slightly higher results for US-RASP compared to non-US-RASP (MD 2.01, 95% CI: -5.17 to 9.19, p=0.58 and MD 9.09, 95% CI: -22.74 to 40.93, p=0.58, respectively), although with substantial heterogeneity (I^2 =63% and I^2 =51%).[16,17,21-24] The Clavien-Dindo ≤1 meta-analysis with 4 included studies showed a slightly higher results in US-RASP compared to non-US-RASP, despite not being statistically significant (OR 0.81, 95% CI: 0.43 to 1.53, p=0.52).[16,17,22,23] The heterogeneity was considered moderate (I^2 =41%).

DISCUSSION

Although the advancement of technology has led to the development of many methods to treat BPH, OSP still has a place as a method of choice, especially in conditions with prostate size larger than 80 ml.[3] The drawbacks of standard OSP approaches, such as Millin (transcapsular) and Freyer (tansvesical), are associated with greater blood loss, longer catheterization times, and longer hospital stays. Even the ejaculatory dysfunction (EjD) outcomes of this surgery cannot be avoided due to the inevitable injury to the urethra, ejaculatory ducts, and bladder.[7-9] Even endourology methods, such as TURP, HoLEP, and ThuLEP, which are associated with less blood loss, may still have the drawback of EjD.[25] This drawback can be

important for young and sexually active male who still want to preserve their ejaculatory function. In consideration of EjD, many urologists have looked back at history, and the Madigan approach with its urethral preservation methods has caught the attention of urologists. The Madigan approach is known for its complexity, primarily due to the difficulty in developing a space between the adenoma and the urethra, which often results in urethral injury.[26] To date, Madigan approach have been applied with robotic tools in higher precision.[14-17,21-24] However, to the best of the author's knowledge, there is no definitive conclusion on the safety and efficacy of US-RASP in the treatment of BPH, and there are no guidelines recommending the use of US-RASP for the treatment of BPH. Currently, there is no RCT and only a few cohort studies compare US-RASP and non-US-RASP. To our knowledge, this meta-analysis is the first to evaluate the safety and efficacy of US-RASP compared to non-US-RASP. The aim of this study was to assess and compare the sexual, functional, and surgical outcomes of US-RASP and non-US-RASP for treating BPH.

In our study, 80% (69/86) of patients in the US-RASP group preserved their antegrade ejaculation 6 months after surgery, compared with only 11% (9/83) of patients in the non-US-RASP group. The result of ejaculatory preservation was consistent with the results of Simone et al and Wang et al, who reported ejaculatory preservation rates of 66% (8/12) and 93% (13/14), respectively.[14,15] The median age between the two studies included in our 6-month ejaculatory preservation meta-analysis was also similar, as shown in Table 1.[17,24] In addition, this meta-analysis also yielded statistically significant results in favor of US-RASP. This was also consistent with the results of our other meta-analysis, where the US-RASP had relatively higher scores on the IIEF-5 and MSHQ-EjD-SF questionnaires 12 months after surgery. In a normal prostate, ejaculatory function is known to involve 3 physiological phases: preparation, emission, and expulsion.[27] The emission and expulsion phases are thought to occur due to patent ejaculatory ducts and the "anti-reflux" mechanism maintained by the sphincter area in the pre-prostatic segment of the posterior urethra above the verumontanum, known as the "genital sphincter".[27] Although the hypertrophied prostate glands may not produce adequate volume of secretion and the ejaculatory ducts may form acute angulations and become obstructed, the ejaculatory ducts and "genital sphincter" area, both of which can still be injured during a standard SP approach and may result in retrograde ejaculation (RE) or EjD after surgery.[27,28] Shin et al hypothesized that the failure of ejaculatory preservation in their study, as well as in others, could be due to thermal injury to the ejaculatory ducts in the central zone during coagulation of the posterior bed after adenoma removal, or damage to the longitudinal smooth muscle fibers of the prostatic urethra, which may affect the emission phase.[24] However, by preserving the verumontanum and surrounding tissues, including the paracollicular tissue, antegrade ejaculation may be preserved.[28] Regarding the anatomical considerations for preserving antegrade ejaculation, it is noteworthy that the main challenge in US-RASP is avoiding injury to the relevant anatomy, especially the ejaculatory ducts. Dixon et al stated that the urethral catheter inserted can be palpated, which helps identify the urethra.[10] However, the urologist cannot feel the projection of the catheter through the robotic arms.[15] Therefore, Simone et al and Bove et al used a near infrared fluorescence (NIFI) guidance for better visualization, with an injection of indocyanine green through the urethral catheter.[14,16,23] This results in indocyanine green reflux in the ejaculatory ducts, which produces a green color in close proximity to the distal urethra.

Despite the advancement of robotic technology and NIFI guidance, urethral preservation remains a difficult task.[14] Unintentional injury to the urethra can still occur due to: the urethral wall being very thin, caused by the loss of muscular fiber architectural structures; the posterior development of the adenoma behind the posterior wall; or the presence of a median lobe adenoma that is adherent to the posterior wall of the proximal urethra.[17] In addition, the surface of the median lobe is only covered by a thin layer of mucosa, which tends to be easily torn during dissection of the adenoma, making suture repair of this structure very difficult.[15] In patients with a large lateral lobe and/or median lobe that protrudes into the bladder neck, the urologist would faces the dilemma of whether to perform complete resection, with the risk of injuring the urethra and bladder neck, or whether to perform incomplete resection, with the risk of recurrence of obstructive symptoms related to BPH.[14] Wang et al recommended a sustained upward traction on the median lobe during dissection to facilitate exposure and countertraction; applying slow and gentle blunt dissection to separate the mucosal layer from the median lobe; performing step-by-step removal of the median lobe in small pieces; and using real-time transrectal ultrasonography (TRUS) to ensure no adenoma remains.[15] Therefore, Porpiglia et al performed an additional longitudinal incision in the bladder neck with upward traction to dissect the median lobe adenoma.[17] In our study, the results for IPSS, Q_{max}, and PSA 12 months after surgery were similar between the US-RASP and non-US-RASP groups. However, there was a statistically significant result of a higher 12-month PVR in the US-RASP group. Although this result may not be clinically significant, it might indicate an incomplete enucleation of the adenoma in the US-RASP group. Furthermore, this result must be also considered in the context of the fact that only studies by Porpiglia et al and Fiori et al included patients with median lobe enlargement in the US-RASP group.[17,21]

One thought regarding US-RASP is that the complexity of preserving the urethra may significantly increase operative time and blood loss. However, our study's meta-analysis results showed similar operative time and blood loss, with US-RASP tend to have 2 minutes longer operative time and 9 ml more blood loss compared to non-US-RASP. This may be due to the variability in the urologist's

experience and patient factors. Our study's meta-analysis also showed similar outcomes between US-RASP and non-US-RASP in terms of no complications or Clavien-Dindo grade 1. Only 10% (24/231) of patients in the US-RASP group were classified as Clavien-Dindo grade >1, compared to 8% (19/218) in the non-US-RASP group. This result is consistent with a meta-analysis conducted by Pandolfo et al, which reported similar overall complications between RASP and EEP, and a meta-analysis by Shuai et al, which also found similar overall complications between RASP and laser EEP.[13,29] Our study's meta-analysis also showed a statistically significant reduction in catheterization time and length of stay in the US-RASP group compared to the non-US-RASP group. This may be due to the nature of urethral preservation, which reduces trauma and inflammation associated with the urinary tract, thus reducing the need for postoperative continuous bladder irrigation, which shortens catheterization time and length of stay.[24] These results suggest the safety and efficacy of US-RASP, with similar operative time, blood loss, and complication rates compared to non-US-RASP. Therefore, the advantages of shorter catheterization time and length of stay for US-RASP may encourage urologists to consider this approach for treating BPH.

Limitations

This review acknowledges several limitations. First, this study did not differentiate between the US-RASP approaches used in the included studies. Some studies exhibited variability in their techniques, such as the transperitoneal approach or extraperitoneal approach; the use of NIFI and TRUS guidance; the application of an additional bladder longitudinal incision to overcome median lobe adenoma; and some patients in the US-RASP group had partial injury to the urethra, requiring partial reconstruction to preserve it.[16,17,21-24] This study also did not include only the Millin technique, which has a transcapsular nature similar to the Madigan technique, but also the Freyer technique, which is a transvesical method, as a comparison in the non-US-RASP group. Second, the lack of RCT studies and the reliance on observational studies may lower the overall level of evidence. The risk of bias in the three included studies was categorized as "moderate" due to the non-inclusion of median lobe enlargement in the US-RASP group, which could lead to selection bias.[16,22,23] Third, most of the surgical outcomes meta-analyses showed moderate-to-high heterogeneity, which may affect the stability of our results. Fourth, the relatively low patient numbers in the included studies may limit the applicability of our results to a wider population.

CONCLUSION

In this systematic review and meta-analysis, the authors conclude that US-RASP can be considered as a safe and effective alternative choice from non-US-RASP to treat BPH. Although the complexity and challenge to preserve the urethra in US-RASP, with favorable sexual outcomes including greater number of 6-month ejaculatory preservation, 12-month MSHQ-EjD SF, and favorable surgical outcomes of shorter catheterization time, length of stay, US-RASP can be a choice for young, sexually active male patients. However, the consideration of relatively higher 12-month PVR can be a drawback for US-RASP. Further research with larger patients, and well-designed RCT is needed to confirm these findings.

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