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Transcutaneous electrical acupoint stimulation for prevention of postoperative urinary retention: A systematic review

Kai-Yu Huang [a], Shuang Liang [a,*], Han-Guang Du [b], Yong-Yi Xu [a], Lei Chen [a], Yi Zhang [a], Xin-Xin Feng [a]

[a] *Acupuncture Department, Ningbo Hospital of Traditional Chinese Medicine, Affiliated Hospital of Zhejiang Chinese Medical University, Ningbo, China*
[b] *Endocrinology Department, Ningbo Hospital of Traditional Chinese Medicine, Affiliated Hospital of Zhejiang Chinese Medical University, Ningbo, China*

A R T I C L E I N F O

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Meta-analysis

A B S T R A C T

Introduction: Transcutaneous electrical acupoint stimulation (TEAS) has been proposed for post-operative urinary retention (POUR). This meta-analysis evaluated the effect of TEAS in preventing POUR.
Methods: Databases were searched until February 6, 2023. Randomized controlled trials (RCTs) about TEAS for preventing POUR were included. The primary concern was the incidence of POUR, with post-void residual urine volume as a secondary outcome.
Results: Fourteen studies with 2865 participants were identified. TEAS reduced the incidence of POUR (RR = 0.44, 95%CI = 0.33 to 0.58, $P < 0.00001$) and decreased the post-void residual urine volume (MD = −75.41 mL, 95%CI = −118.76 to −32.06, $P = 0.0007$). The preventive effect on POUR was found in patients receiving anorectal, gynecologic, orthopedic and biliary surgery, but not urinary surgery. Dilatational- and continuous-wave TEAS had a great outcome in preventing POUR. Intraoperative TEAS, preoperative and intraoperative TEAS, and postoperative TEAS were beneficial, and TEAS was more beneficial when compared with sham TEAS and blank control. It is nevertheless difficult to rule out publication bias.
Conclusions: TEAS could prevent POUR. Due to insufficient evidence, multicenter, large-sample and high-quality RCTs should be conducted. (Registration:INPLASY202320095).

1. Introduction

Urinary retention is a common post-surgery complication [1]. The development of postoperative urinary retention (POUR) is influenced by factors such as age, sex, comorbidities, operative time and so on [2,3]. Concurrent diseases such as benign prostatic hyperplasia, urological diseases, diabetes mellitus, stroke and multiple sclerosis are predisposing factors [4]. The prolonged duration of the surgery is related to its complexity, and increases the risk of bladder dysfunction [5]. Catheterization is a common treatment for POUR. But this procedure is invasive, thereby elevating the likelihood of infection and trauma [6]. Neglecting to treat POUR can result in bladder over-distension, prolonged hospitalization, and escalated healthcare expenses [7]. Consequently, surgeons have

* Corresponding author.
E-mail addresses: huangkaiyu0728@qq.com (K.-Y. Huang), liangshuang0803@qq.com (S. Liang), 95331570@qq.com (H.-G. Du), xuyyi1280@126.com (Y.-Y. Xu), chenlei196601@sina.com (L. Chen), yizhi6955288@163.com (Y. Zhang), xinduanq41100000@126.com (X.-X. Feng).

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acknowledged the significance of implementing preventive measures.

There was some evidence that using alpha-blockers and nonsteroidal anti-inflammatory drugs, reducing exposure to morphine in a regional anesthetic regimen, and a preference for epidural anesthesia over spinal anesthesia were the main pharmacological interventions for prevention of POUR [8]. There was also some evidence that some non-pharmacological interventions such as early mobilization and fluid restriction reduced the risk of POUR [8]. Alpha-blockers, benzodiazepines drugs and cholinergic drugs are the main pharmacological treatments, and besides catheterization, local hot compress is the main non-pharmacological way for treating POUR [8]. While the clinical efficacy, cost-effectiveness, safety and patient acceptance of these treatments need to be further evaluated.

Transcutaneous electrical acupoint stimulation (TEAS) is widely used to prevent post-surgery complications, such as postoperative delirium [9], subsyndromal delirium [10], postoperative cognitive dysfunction [11], postoperative gastrointestinal dysfunction [12] and postoperative nausea and vomiting [13]. Moreover, TEAS has demonstrated benefits in preventing catheter-related bladder discomfort [14]. TEAS has some advantages over conventional interventions. As a non-invasive treatment, TEAS is safe and more acceptable to surgical patients. Additionally, TEAS can be easily managed and conducted by healthcare personnel who have received fundamental training. Thus, TEAS has been proposed to be used for the treatment of urination disorders including POUR. Recently, some published trials have supported the preventive effect of TEAS on POUR [15]. However, there has been no comprehensive assessment of the impact of TEAS on POUR in accordance with the PRISMA guideline. In view of this, a meta-analysis was performed to evaluate the effect of TEAS in preventing POUR.

2. Methods

This review followed the PRISMA 2020 statement checklist [16], and was registered with INPLASY (INPLASY202320095).

2.1. Search strategy

Searching four key databases, including the China National Knowledge Infrastructure (CNKI), WanFang, Pubmed and CENTRAL, proved to be a highly effective approach for acquiring acupuncture randomized controlled trials (RCTs) [17]. These four key databases were searched until February 6, 2023. RCTs about TEAS for preventing POUR were included. The search terms were “postoperative urinary retention”, “postoperative urination disorders”, “postoperative uroschesis”, “uroschesis”, “urinary retention”, “urination disorders”, “transcutaneous electrical acupoint stimulation” and “acustimulation”. Appendix A shows the search strategy.

2.2. Eligibility criteria

Population: surgical patients; intervention: TEAS; comparison: blank or sham TEAS; outcome: POUR; and study design: RCTs published in journals. The primary concern was the incidence of POUR, with post-void residual urine volume as a secondary outcome. For duplicate studies, only the newest was considered.

2.3. Study selection and data extraction

Eligible articles were independently evaluated for inclusion by two reviewers (KYH and SL). The following information was extracted: first author, publication year, patient demographics, details of TEAS and control, and outcome measures. The third reviewer (HGD) arbitrated disagreements.

2.4. Risk of bias assessment

Two reviewers (KYH and SL) individually employed the Cochrane Collaboration tool to evaluate selection bias, performance bias, detection bias, attrition bias, reporting bias and other bias [18]. The third reviewer (HGD) arbitrated disagreements.

2.5. Data synthesis

The software tools employed in this study included RevMan 5.3 and Stata 13.0. For assessing dichotomous outcomes (the incidence of POUR), the analysis utilized risk ratio (RR) with 95 % confidence interval (CI). For assessing continuous outcomes (the post-void residual urine volume), the analysis utilized mean difference (MD) with 95 % CI. A random-effects model was adopted regardless of heterogeneity, with I^2 test employed for assessing heterogeneity. We performed subgroup analyses by categorizing surgeries, TEAS waveforms, TEAS timing and control methods. If no less than 10 RCTs were included, publication bias was evaluated using a combination of a funnel plot and Egger’s test [19].

3. Results

3.1. Study selection

Two thousand and eighty-six citations were identified. The count reduced to 1449 after removing duplicate records. Exclusion of

1428 records occurred after reviewing titles and abstracts. By checking complete textual documents, 7 reports were excluded due to not RCTs (n = 2), ineligible intervention (n = 2), ineligible outcome (n = 2) and duplicate publication (n = 1). Appendix B lists the 7 reports excluded by checking complete textual documents. Finally, this review included fourteen studies [20–33]. Fig. 1 displays the process of study selection.

3.2. Study characteristics

Fourteen studies with 2865 participants were identified. The types of surgery included biliary surgery [20], anorectal surgery [21,24,25,27,29,31], gynecologic surgery [22,23,26], orthopedic surgery [28,30,32], and urinary surgery [33]. All studies provided data on the incidence of POUR [20–33], and two reported information on post-void residual urine volume [23,26]. Table 1 presents the study attributes.

3.3. Details of TEAS and control

One study adopted intraoperative TEAS [24], four adopted preoperative and intraoperative TEAS [23,26,28,33], two adopted preoperative, intraoperative and postoperative TEAS [20,27], and the remaining seven used postoperative TEAS [21,22,25,29–32]. Regarding TEAS waveforms, dilatational wave [21,24,26,27,30–33] and continuous wave [20,23,28,29] were commonly used. Two studies did not report the detailed information about TEAS waveforms [22,25]. For stimulation frequency, 2/100Hz was the most popular. In all included studies, the stimulation sites were traditional acupoints. ST36 (*Zusanli*), SP6 (*Sanyinjiao*), CV3 (*Zhongji*), and CV4 (*Guanyuan*) were widely utilized in practice.

Ten studies used blank control [22–29,31,32], and four adopted Sham TEAS as a control [20,21,30,33]. In three studies, the electrodes were attached to the acupoints but the output wires were cut off [20,30,33]. The remaining one applied disposable electrodes to non-acupoint skin area with electrical current output [21].

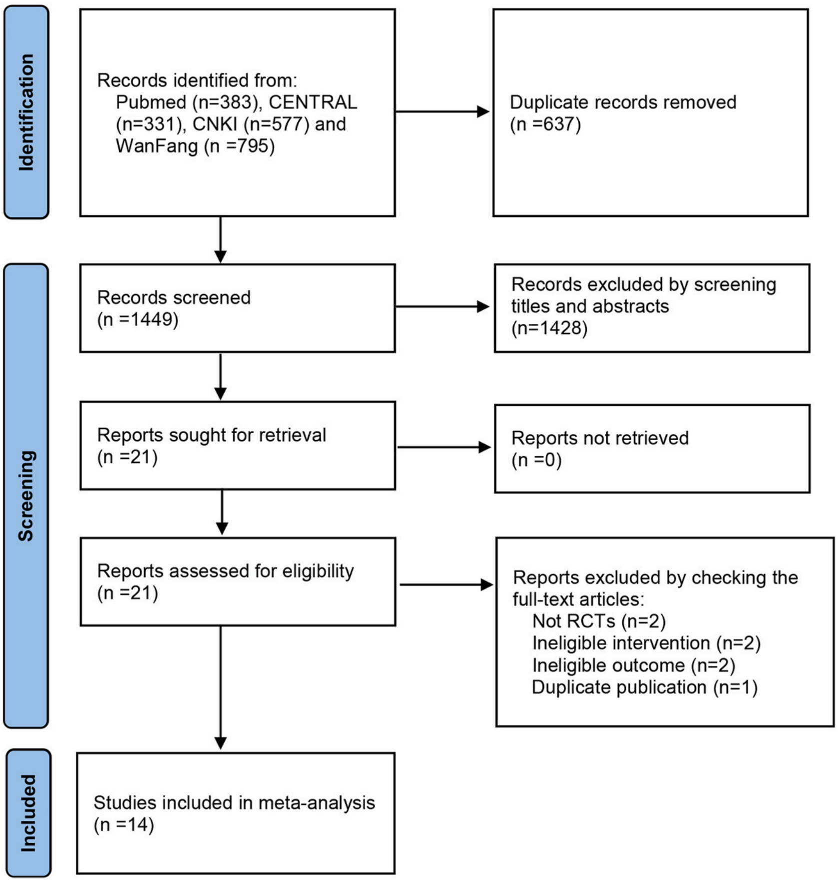

Fig. 1. Flow diagram of the study selection process.

Table 1
Characteristics of the included studies.

Study	Sample size (TEAS/ Control)	Type of surgery	TEAS group	Control group	Outcomes
Zhang 2023 [20]	1838 (922/ 916)	Biliary surgery	TEAS; BL32, SP6, CV3, CV4; continuous wave, 2Hz; 30min before anesthesia till 45min after surgery	Sham TEAS	Incidence of POUR
Chiu 1999 [21]	60 (30/30)	Anorectal surgery	TEAS; LI4, LU7; dilatational wave, 2/100Hz; twice a day after surgery, stimulation for 30min each time	Sham TEAS	Incidence of POUR
Wang 2021 [22]	72 (36/36)	Gynecologic surgery	TEAS; ST36, SP6, ST28; TEAS waveform was not reported; once a day after surgery for 2 weeks, stimulation for 30min each time	Blank control	Incidence of POUR
Zhang 2016 [23]	50 (25/25)	Gynecologic surgery	TEAS; SP6, SP9, ST36; continuous wave, 2Hz; 30min before anesthesia till the end of surgery	Blank control	Incidence of POUR; post-void residual urine volume
Wang 2022 [24]	100 (50/50)	Anorectal surgery	TEAS; PC6, ST36; dilatational wave, 2/100Hz; from anesthesia to the end of surgery	Blank control	Incidence of POUR
Shen 2017 [25]	110 (55/55)	Anorectal surgery	TEAS; BL57, ST36, GV1, CV3; TEAS waveform was not reported; once a day after surgery for 1 week, stimulation for 15–20min each time	Blank control	Incidence of POUR
Dang 2012 [26]	40 (20/20)	Gynecologic surgery	TEAS; SP9, SP6, BL32, BL54; dilatational wave, 2/100Hz; 20min before anesthesia till the end of surgery	Blank control	Incidence of POUR; post-void residual urine volume
Chen 2022 [27]	100 (50/50)	Anorectal surgery	TEAS; PC6, LI4; dilatational wave, 2/100Hz; 20–30min before anesthesia till the end of surgery, and once a day after surgery for 3 days, postoperative stimulation for 30min each time	Blank control	Incidence of POUR
Zhou 2019 [28]	60 (30/30)	Orthopedic surgery	TEAS; PC6, LI4, CV4, CV3; continuous wave, 10Hz; 30min before anesthesia till the end of surgery	Blank control	Incidence of POUR
Shen 2020 [29]	90 (45/45)	Anorectal surgery	TEAS; BL30; continuous wave, 300Hz; once on the day of surgery and twice a day after surgery for seven days, stimulation for 30min each time	Blank control	Incidence of POUR
Wang 2017 [30]	62 (31/31)	Orthopedic surgery	TEAS; GB30, GB31, ST36; dilatational wave, 2/10Hz; once on the day of surgery and once two days after surgery, stimulation for 30min each time	Sham TEAS	Incidence of POUR
Xu 2016 [31]	97 (50/47)	Anorectal surgery	TEAS; CV3, CV4, BL31, BL32, BL33, BL34, BL23, BL28, BL35; dilatational wave, 2/20Hz; 1 h after surgery, stimulation for 30min	Blank control	Incidence of POUR
Zhou 2015 [32]	80 (40/40)	Orthopedic surgery	TEAS; LI4, PC6, ST36, SP6; dilatational wave, 2/15/100Hz; 0, 2, 24, and 48 h after surgery, stimulation for 30min each time	Blank control	Incidence of POUR
Guo 2022 [33]	106 (53/53)	Urinary surgery	TEAS; CV3, CV4, ST36, SP6; dilatational wave, 2/15Hz; 30min before anesthesia till the end of surgery	Sham TEAS	Incidence of POUR

Abbreviations: TEAS, transcutaneous electrical acupoint stimulation; POUR, postoperative urinary retention.

3.4. Risk of bias

Fig. 2 and Appendix C showed the risk of bias assessment. Twelve studies described sufficient details of randomization [20–25,27–30,32,33], and the remaining two only mentioned randomization [26,31]. Only one study emphasized allocation concealment [20]. In four studies, a blinding technique was implemented for both the subjects and operators [20,21,30,33], and only one provided details on how outcome assessments were blinded [20]. All the studies with case dropouts described detailed reasons. There was only a single study conducted in accordance with the prescribed protocols, so the selective reporting was judged as "low risk" [20].

3.5. Effects on the incidence of POUR

The incidence of POUR was documented in all RCTs [20–33]. The incidence of POUR in TEAS groups was 8.42 % (121/1437), and that in control groups was 16.88 % (241/1428). The meta-analysis demonstrated TEAS exhibited a significant reduction in the incidence of POUR (n = 2865; RR = 0.44, 95%CI = 0.33 to 0.58, $P < 0.00001$, Fig. 3), exhibiting minimal heterogeneity ($I^2 = 21$ %, $P = 0.22$).

Subgroup analyses were performed. Fig. 4 demonstrated TEAS had a significant preventive effect on POUR in patients receiving anorectal (RR = 0.34, 95%CI = 0.23 to 0.50, $P < 0.00001$), gynecologic (RR = 0.47, 95%CI = 0.30 to 0.72, $P = 0.0006$), orthopedic (RR = 0.17, 95%CI = 0.04 to 0.73, $P = 0.02$) and biliary surgery (RR = 0.72, 95%CI = 0.54 to 0.95, $P = 0.02$). However, no significant preventive effect was observed in urinary surgery cases (RR = 0.50, 95%CI = 0.05 to 5.35, $P = 0.57$). The results presented in Fig. 5 indicated that both dilatational-wave TEAS (RR = 0.35, 95%CI = 0.23 to 0.54, $P < 0.00001$) and continuous-wave TEAS (RR = 0.51, 95%CI = 0.32 to 0.82, $P = 0.005$) had a great outcome in preventing POUR. Fig. 6 demonstrated that intraoperative TEAS had a

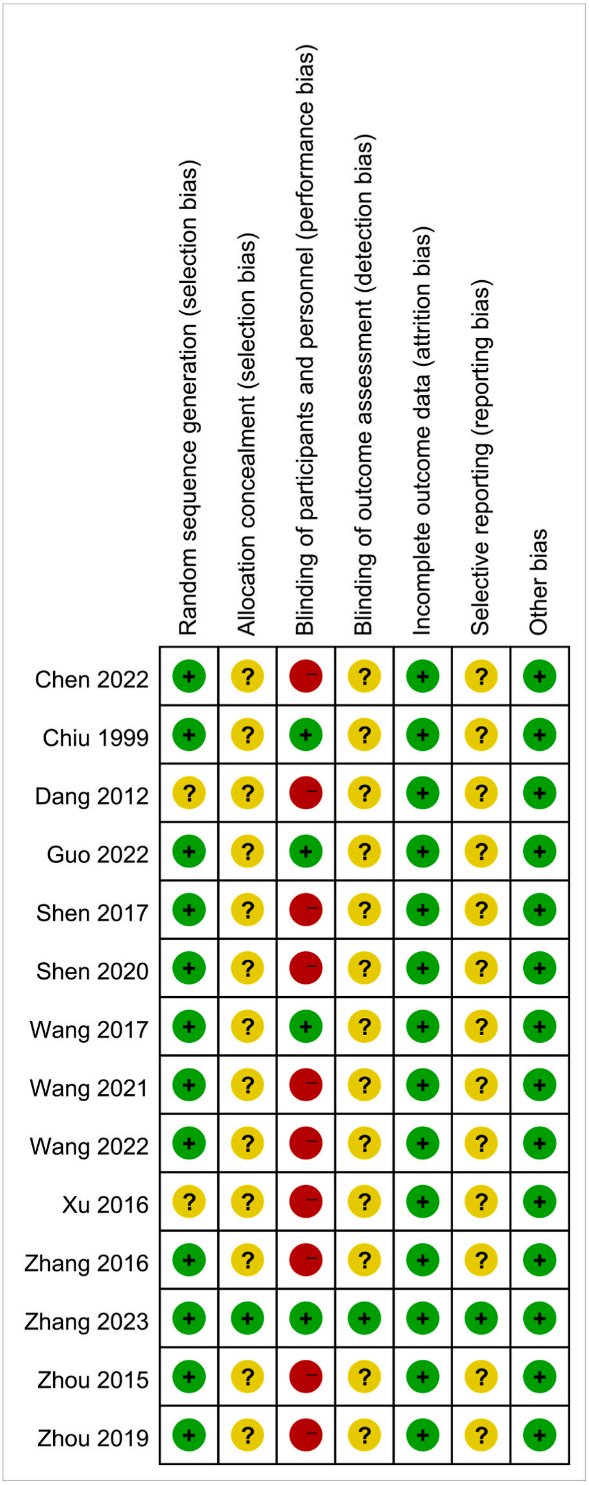

Fig. 2. Risk of bias summary.

positive effect (RR = 0.18, 95%CI = 0.04 to 0.78, $P = 0.02$), as did preoperative and intraoperative TEAS (RR = 0.48, 95%CI = 0.31 to 0.74, $P = 0.001$) and postoperative TEAS (RR = 0.35, 95%CI = 0.23 to 0.52, $P < 0.00001$). However, the combined use of preoperative, intraoperative and postoperative TEAS did not show significant benefits (RR = 0.47, 95%CI = 0.16 to 1.38, $P = 0.17$). The results presented in Fig. 7 indicated that TEAS demonstrated greater preventive effect compared with sham TEAS (RR = 0.68, 95%CI = 0.52 to

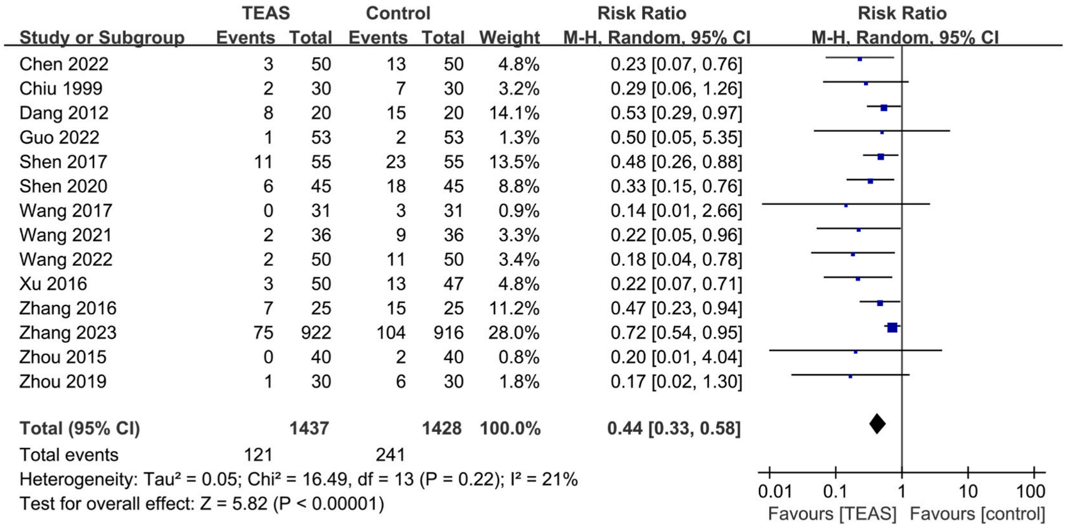

Fig. 3. Forest plot of the incidence of POUR.

0.90, $P = 0.006$) and blank control (RR = 0.39, 95%CI = 0.29 to 0.52, $P < 0.00001$).

3.6. Effects on the post-void residual urine volume

Only two studies reported the post-void residual urine volume [23,26]. Fig. 8 demonstrated TEAS could decrease the post-void residual urine volume (n = 90; MD = −75.41 mL, 95%CI = −118.76 to −32.06, $P = 0.0007$), exhibiting minimal heterogeneity ($I^2 = 0$ %, $P = 0.81$).

3.7. Publication bias

It is difficult to exclude the possibility of publication bias based on the findings from a funnel plot (Fig. 9) and Egger's test ($P < 0.0001$).

4. Discussion

This review represents the first investigation of the effect of TEAS in preventing POUR. Fourteen studies with 2865 participants were included. Our results showed that TEAS could lower the occurrence of POUR and decrease the post-void residual urine volume. According to subgroup analyses, TEAS had a significant preventive effect on POUR in patients receiving anorectal, gynecologic, orthopedic and biliary surgery, but not urinary surgery; both dilatational-wave and continuous-wave TEAS had a great outcome in preventing POUR; intraoperative TEAS had a positive effect, as did preoperative and intraoperative TEAS and postoperative TEAS; and TEAS was more beneficial when compared with sham TEAS and blank control. However, the limited quality of the studies and the possible publication bias undermine our certainty regarding the effect of TEAS in preventing POUR.

A growing number of clinical studies are providing evidence in favor of utilizing TEAS to promote postoperative recovery [34,35]. TEAS is simple to use, non-invasive, and safe. Besides, TEAS parameters such as acupoint selection, waveform and frequency are easy to report in RCTs and duplicate [9]. In this review, dilatational wave was more commonly used than continuous wave. Dilatational wave can improve metabolism, blood circulation and muscle weakness. In contrast, the use of continuous wave can cause muscles to contract and stimulate sensory and motor nerves. Therefore, dilatational wave was frequently used to facilitate postoperative rehabilitation [36]. For stimulation frequency, 2/100Hz was the most popular. The application of 2Hz can promote the release of enkephalins and endorphins in the brain. The application of 100Hz can promote the release of dynorphin in spinal cord. And the application of 2/100Hz dilatational wave can stimulate the body to release endorphins, enkephalins and dynorphin at the same time, resulting in synergies [37]. In regards to acupoint selection, ST36 (*Zusanli*), SP6 (*Sanyinjiao*) and CV3 (*Zhongji*) were the most commonly used acupoints. Stimulation at ST36 (*Zusanli*) and SP6 (*Sanyinjiao*) could improve bladder function and decrease bladder sensory loss [38]. As the Mu point of the bladder meridian, CV3 (*Zhongji*) is the key acupoint for urinary diseases. An animal experiment has confirmed that acupuncture at CV3 (*Zhongji*) could normalize the abnormal intravesical discharge rate [39].

TEAS causes both real therapeutic effects and placebo effects. It is necessary to set up a sham group in TEAS RCTs in order to exclude placebo effects and better observe the therapeutic effects of TEAS [40]. In this systematic review, four studies adopted sham TEAS [20,21,30,33]. Three studies attached the electrodes to the acupoints but the output wires were cut off [20,30,33], and the remaining one used electrical stimulation at non-acupoint skin area [21]. Meta-analysis showed TEAS was more effective than sham TEAS in reducing the incidence of POUR. This outcome implied that the specific effects of TEAS played a significant role in the

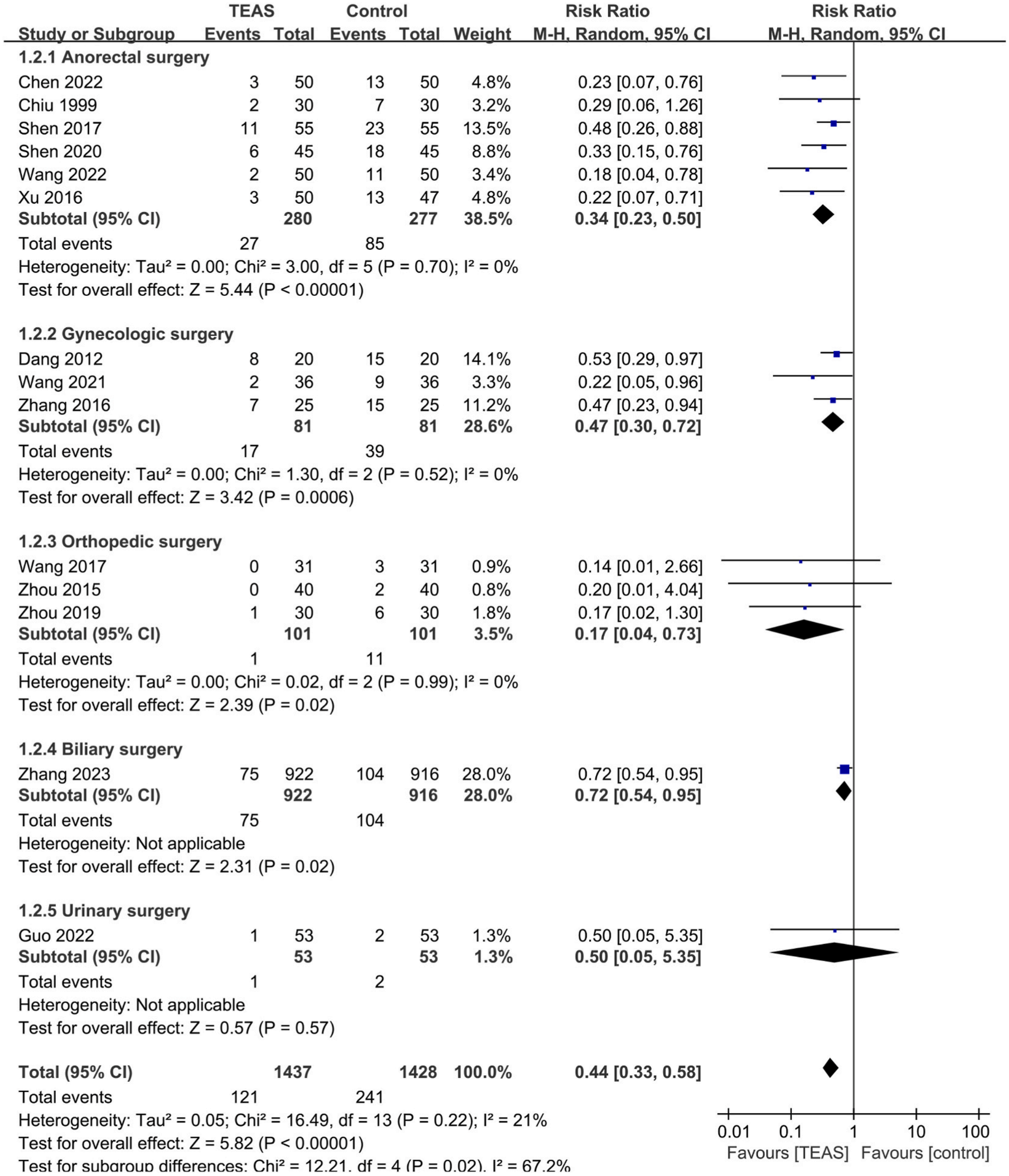

Fig. 4. Subgroup analysis of the incidence of POUR based on different types of surgery.

therapeutic response. In the subgroup analysis based on different control methods, significant subgroup differences were found ($P = 0.006$) between TEAS vs. sham TEAS and TEAS vs. blank control. It could be hypothesized that this finding confirmed the placebo effects of sham TEAS.

TEAS is a potential intervention for double-blind acupoint stimulation. In this review, the most commonly used method to sham TEAS is utilizing identical apparatus without electrical output. To further reduce the performance bias in the RCTs, both the assignment and treatment should be concealed from patients and clinical assessors. Patients should keep their eyes shut and refrain from sharing their therapy encounters with fellow patients. And operators are required to finish either true TEAS or sham TEAS under the guidance of the trial manager and strictly abide by the signed confidentiality agreement. In addition, we propose implementing blinding of the connection between the acupoint electrical stimulator and the output wire, with only the trial manager being aware of whether the output wire is accurately connected to the acupoint electrical stimulator.

The possible mechanisms of TEAS for preventing POUR are very interesting. General anesthetics can inhibit vagus and sympathetic nerve activity and attenuate autonomic control of urinary function. As a co-transmitter with noradrenaline and acetylcholine, ATP can stimulate afferent nerve activity and result in bladder sensation, and has been considered a potential target for preventing POUR [41].

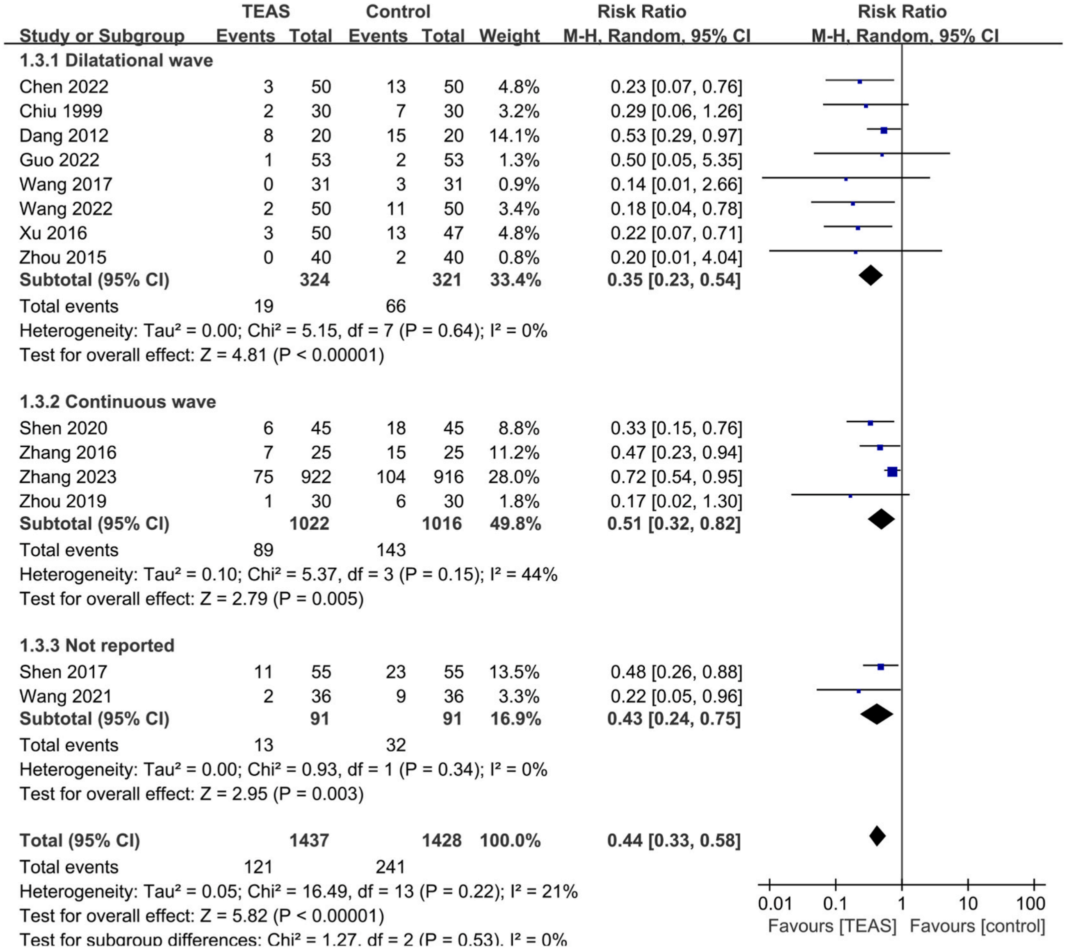

Fig. 5. Subgroup analysis of the incidence of POUR based on different TEAS waveforms.

One study discovered the possible mechanism of TEAS for POUR is to increase ATP release and improve spontaneous urination reflex recovery [15]. TEAS, like acupuncture, has the potential to modulate urination by altering the firing properties of neurons associated with bladder activity [42].

Strengths are listed. It represents the first comprehensive investigation of the effect of TEAS in preventing POUR. A standardized systematic review protocol was registered with INPLASY. We tried best to include all relevant RCTs by the well-designed search strategies. The methodological quality of RCTs was assessed in various aspects through risk of bias assessment, funnel plot analysis, and Egger's test. To enhance the reliability of the conclusion, subgroup analyses were performed considering various surgeries, waveforms, treatment time and controls.

Limitations are described below. Firstly, the methodological quality of the included RCTs was generally low. Only one study emphasized allocation concealment. About 28 % of the included studies implemented a blinding technique for both the subjects and operators, and the vast majority of studies didn't provide details on how outcome assessments were blinded. Only a small minority of RCTs were conducted with pre-registration. Secondly, all RCTs were carried out in Asia, potentially leading to publication and region bias, and may affect the validity and reliability of the systematic review. Thirdly, acupoint selection, waveform, frequency, intensity and other TEAS parameters are not uniform in the included studies, which may contribute to high heterogeneity and affect the quality of evidence. Besides TEAS waveforms and TEAS timing, we were unable to conduct subgroup analysis for other potential factors. Fourthly, the network meta-analysis was not conducted, thus failing to summarize the optimal TEAS regimen for preventing POUR. Considering the limited number of included RCTs and the large variation in stimulus parameters (frequency, acupoints, and treatment time) between studies, it was expected that the network meta-analysis based on existing studies would be unreliable, as they were predominantly drawn from circumstantial evidence. When more high-quality RCTs are published in the future, it will make sense to conduct the network meta-analysis. Fifthly, no follow-up details have been provided, and the long-term impact of TEAS is undefined.

Implications for future clinical research are as follows. Researchers are recommended to conduct and report their RCTs according to the CONSORT statement and follow the STRICTA guideline for higher quality of RCTs about TEAS for POUR. The optimal TEAS parameters need to be tested. Furthermore, multicenter, large-sample and high-quality RCTs need to be designed and conducted in the future.

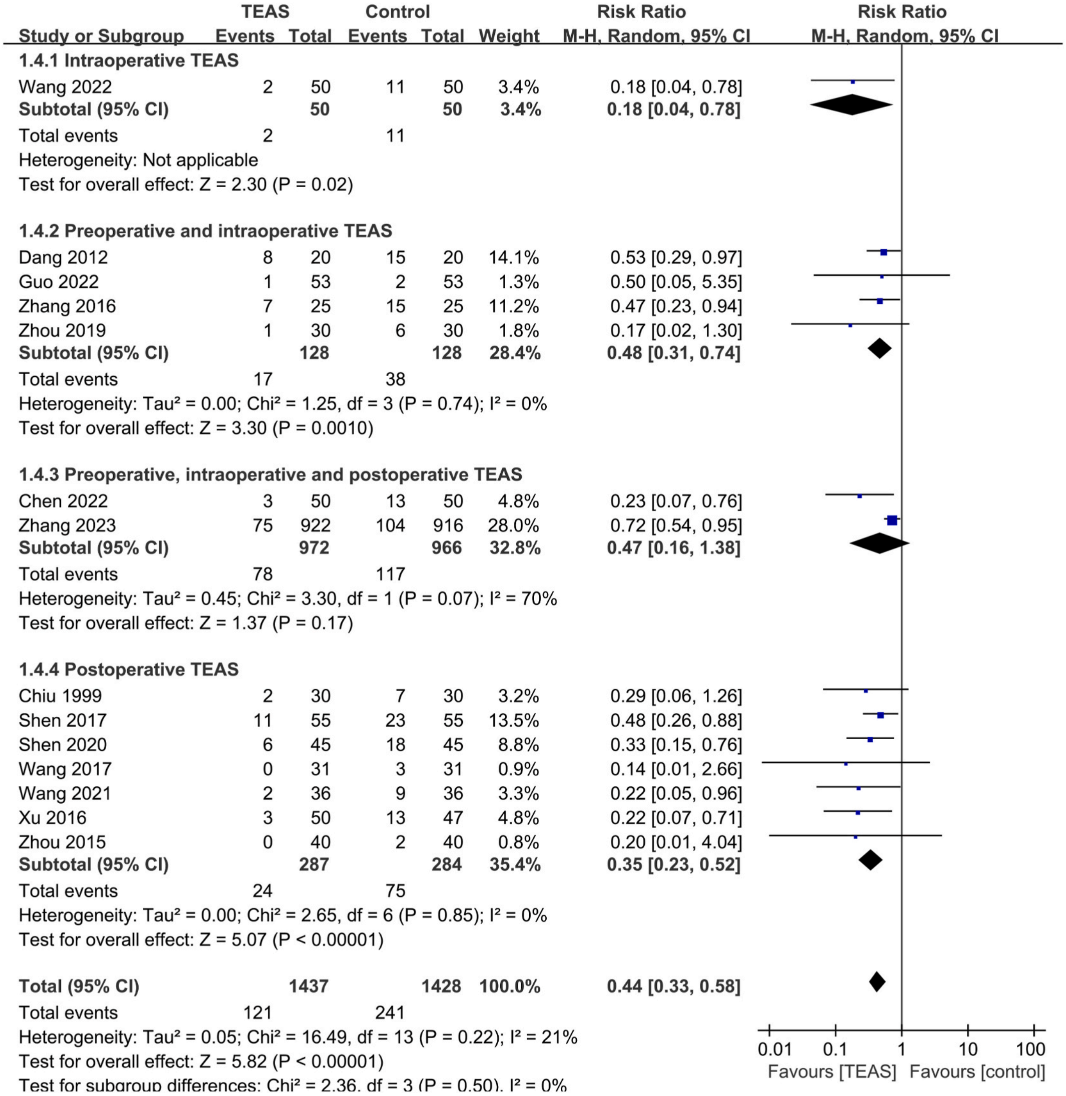

Fig. 6. Subgroup analysis of the incidence of POUR based on different TEAS timing.

5. Conclusions

TEAS could prevent POUR. Due to insufficient evidence, multicenter, large-sample and high-quality RCTs should be conducted.

Funding statement

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Data availability statement

Data associated with this study has not been deposited into a publicly available repository. Data included in article/supplementary material/referenced in article.

Ethics statement

Not applicable.

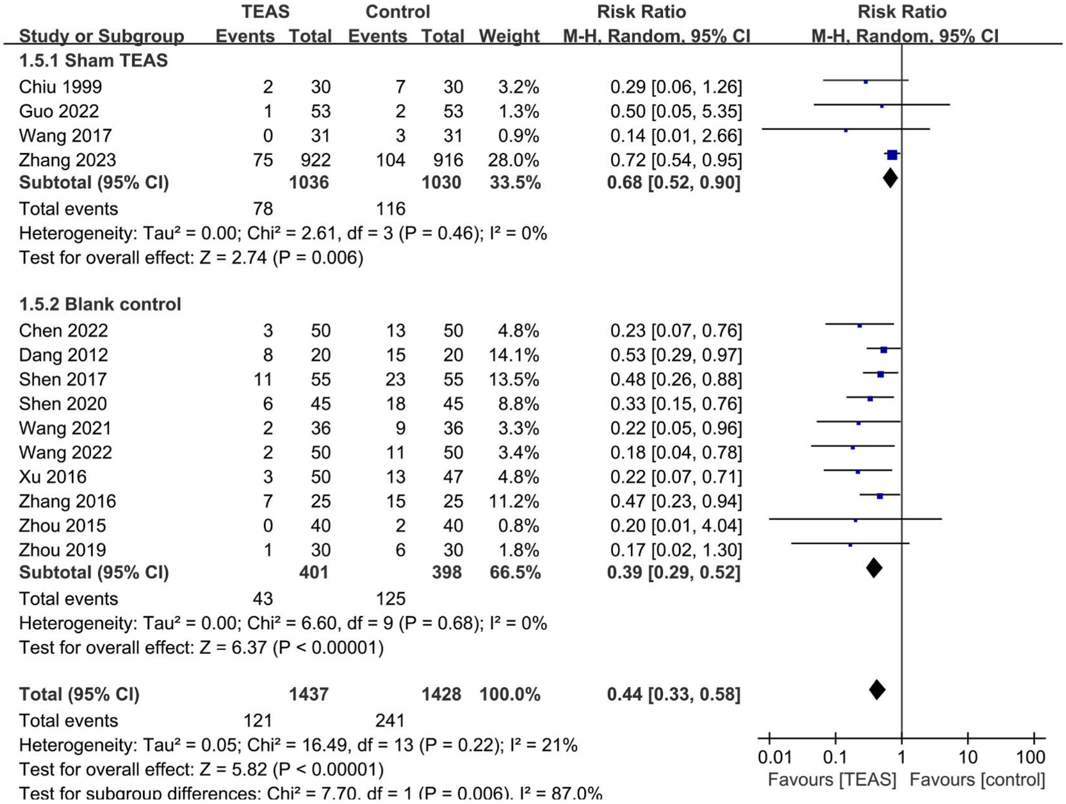

Fig. 7. Subgroup analysis of the incidence of POUR based on different control interventions.

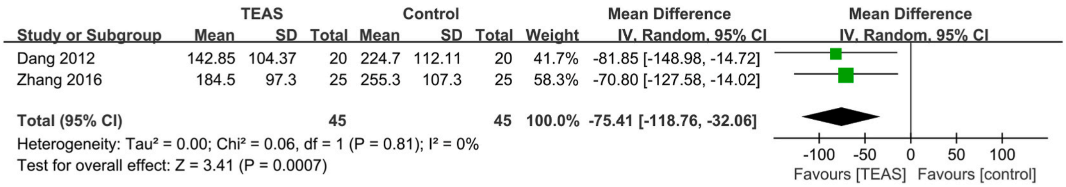

Fig. 8. Forest plot of the post-void residual urine volume.

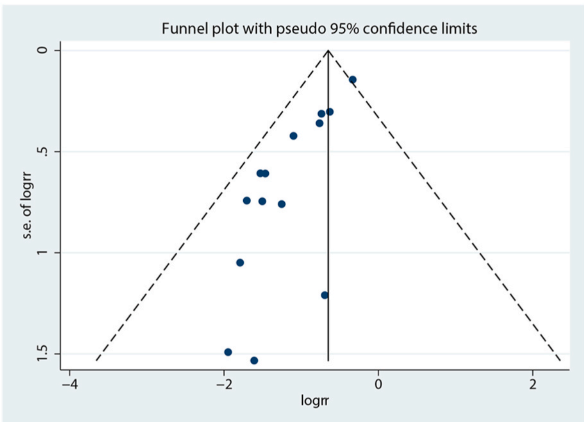

Fig. 9. Funnel plot of the incidence of POUR.

CRediT authorship contribution statement

Kai-Yu Huang: Writing – original draft, Methodology, Investigation, Data curation. **Shuang Liang:** Writing – review & editing, Validation, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Han-Guang Du:** Writing – original draft, Supervision, Methodology, Funding acquisition, Data curation. **Yong-Yi Xu:** Formal analysis. **Lei Chen:** Writing – review & editing, Funding acquisition, Formal analysis. **Yi Zhang:** Writing – original draft, Funding acquisition. **Xin-Xin Feng:** Supervision, Resources.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e23537.

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