Original Article

Do the Necessary to Clamp the Short-term Indwelling Urinary Catheter before Removal among Inpatients? A Meta-analysis of Randomized Controlled Trials

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ABSTRACT

Background

Indwelling Urinary Catheter is frequently used for multiple tasks. It may lead to complications for patients. Moreover, there were no established instructions in clinical practice regarding the use of bladder clamping. Notably, each medical professional decides whether to clamp the catheter prior to removal based on their individual judgment of its necessity.

Objective

Identifying necessary to clamp the short-term indwelling urinary catheter before removal among inpatients.

Materials and Methods

Following PRISMA guidelines. Searches were conducted in the following electronic databases to identify relevant studies: the CINAHL, the Cochrane Library, Embase, Ovid-Medline, PubMed, Scopus, and Web of Science from their inception until February 5, 2023. We manually searched for relevant articles by reviewing the reference lists of included articles. Two authors performed the search independently. Data was analyzed using Comprehensive Meta-Analysis 2.0 and quality assessment was done using ROB 2.0. Continuous variables were analyzed using mean difference and standardized mean difference (SMD) values with a 95% CI. Categorical variables were analyzed using relative risk (RR) and 95% CI.

Results

Eight randomized controlled trials met our inclusion criteria. The Clamping IUC group highly increased the risk of urinary tract infection and needed for re-catheterization, had longer time to first voiding, and produced a smaller first voiding volume compared to the free draining group.

Conclusions

The results from this meta-analysis demonstrated no necessary clamped IUC before removal.

Keywords

Clamping; Indwelling urinary catheter; Urinary tract infection; Meta-analysis.

INTRODUCTION

Indwelling urinary catheters (IUC) are medical devices frequently used for urinary drainage or as the method of collecting urine for measurement [1], approximately 12% to 16% of adult inpatients will have an IUC at some point during their hospitalization [2]. Notably, 63% of catheter-days are accessed, which can result in various complications, such as catheter-associated urinary tract infection (CAUTI), with an incidence rate of 9.86 infections per 1000 catheter-days [3]. The expense associated with a CAUTI can vary considerably depending on the population, severity of the patient's condition, and approach to calculating costs. It is probable that the costs directly linked to a CAUTI are greater than 1,000 US Dollars [4]. A short-term IUC is a catheter that is left in place for 14 days or fewer from the day of insertion [5]. It increased the risk of infection, length of hospital stays and mortality rates. Short-term IUC should be strictly monitored and removed as soon as they are not required.

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Bangladesh Journal of Medical Science Vol. 25 No. 01 January'26

DOI: https://doi.org/10.3329/bjms.v25i1.86426

Clamping training is considered a type of behavioral therapy and has been demonstrated to effectively prevent bladder dysfunction following lower abdominal surgery. This approach involves periodically clamping and releasing the urethral catheter to help retrain the bladder. Consequently, it is recognized as a valuable strategy for managing bladder dysfunction [6]. However, routinely clamping urinary catheters may not be necessary and could actually be harmful, potentially increasing the risk of urinary tract infections or urinary retention and delaying the time to first void in patients whose indwelling urinary catheter (IUC) remains in place for seven days or less, compared to free drainage[7]. Furthermore, previous research suggests that removing indwelling catheters as soon as possible after surgery—without prior bladder training—is recommended [8].

To date, few systematic reviews and meta-analyses have analyzed the need to clamp urinary catheters in patients with short-term IUC (use duration, ≤14 days), though the results were inconsistent. Previous systematic review and meta-analysis found that non-significance differences in the risk of re-catheterization, urine retention, subjective perceptions of patients, the incidence of urinary tract infection, the risk of symptomatic CAUTI and dysuria when comparing the clamping group with the unclamping group [9,10,11]. In contrast, a recently published systematic review and meta-analysis revealed that bladder training by clamping IUC increased the risk of urinary tract infection occurrence and longer hours to first void among patients with IUC use durations of ≤7 days compared with free drainage [7]. Moreover, there were no established instructions in clinical practice regarding the use of bladder clamping. Notably, each medical professional decides whether or not to clamp the catheter prior to removal based on their individual judgment of its necessity. Thus, we conducted a systematic review and meta-analysis of randomized controlled trials (RCTs) to identify the necessity of bladder clamping prior to removal of urinary catheter in patients with short-term IUC. This study aimed to contribute to the growing and yet uncertain body of evidence regarding the efficacy of intermittent clamping for bladder training before IUC removal.

MATERIALS AND METHODS

2.1. Data sources and search strategy

This systematic review and meta-analysis of interventional studies investigated the necessary to clamp the short-term indwelling urinary catheter before removal among inpatients. The protocol was registered in PROSPERO (CRD42023401956). Searches were conducted in the following electronic databases to identify relevant studies: the CINAHL, the Cochrane Library, Embase, Ovid-Medline, PubMed, Scopus, and Web of Science from their inception until February 5, 2023. In addition, we manually searched for relevant articles by reviewing the reference lists of included articles. Two authors performed the search independently, and any discrepancy was solved through discussion with the third author.

2.2. Study eligibility

The participants included adults who had received that 1) urinary catheter was inserted in adult inpatients for up to 14 days; and 2) conducted an intermittent clamping regimen. The comparison group was any type of control group that did not participate in the clamping intervention. The exclusion criteria were as follows: 1) received intermittent catheterization or over 14 days; 2) The use of antibiotic prophylaxis as a primary or secondary outcome; 3) filling fluid into the bladder.

Primary and secondary outcomes

The primary outcomes were catheter-associated urinary tract infection (UTI). Secondary outcomes were time to first voiding, first voiding volume, and need for re-catheterization.

Data extraction and quality assessment

Two reviewers independently extracted the data necessary to calculate the effect sizes; the following study characteristics were gathered from the included trials: first author's name (and study year), country of publication, patients, mean age, percentage of male patients, average duration of indwelling, and Intervention description. The reviewers discussed any disagreements until reaching a consensus. A third reviewer was consulted for adjudication if a consensus was not reached. Additionally, we contacted the authors of primary reports to request any unpublished data.

The two reviewers independently assessed the methodological quality of the included trials by using version 2 of the Cochrane risk of bias (RoB 2.0) tool for randomized trials [11]. Each study was judged to have a high risk, low risk, or some concerns for risk of bias. Discrepancies in judgments were resolved through discussion and consultation with the third reviewer.

Statistical analysis

All statistical analyses were performed using Comprehensive Meta-Analysis 2.0. The mean changes in outcomes from baseline to posttest ware calculated, and the differences between the intervention and control groups were estimated. Considering the differences in participant characteristics, study designs, and interventions [12] , we selected a random-effects model to analyze the pooled effects. Hedges' g and 95% CIs were calculated as the pooled estimates using a random-effects model, and statistical significance was indicated at a two-sided p <0.05. The effect size was interpreted as small (0.2), medium (0.5), large (0.8), or very large (1.2) [13]. Heterogeneity was estimated using Cochran's Q test and I^2 statistics. The statistical significance of heterogeneity was set at $p < 0.05$, and I^2 was interpreted as low (75%) [14] . We conducted a sensitivity analysis by removing one study at a time, thereby identifying which studies affected the variability. A meta-regression analysis with mean age, percentage of males, and average duration of indwelling as independent variables was also implemented. Publication bias was assessed using the Egger's regression test, with significant publication bias indicated at $p < 0.10$. The trim-and-fill method was implemented when significant publication bias existed [15].

RESULTS

Search results A total of 1648 English publications were identified in the initial search (Figure 1). After excluding duplicates and screening the titles and abstracts for eligibility, 48 full-text articles were retrieved for full-text assessment. In total, 8 studies that met the eligibility

criteria were included in the analysis. Figure 1 illustrates the selection process.

Characteristics of included studies

This review included eight RCTs published between 1981 and 2019, comprising 1,720 participants from various countries, including the United States, Europe (Sweden, Greece, Italy), and Asia (China, Korea, Taiwan). The sample sizes across the included studies significantly varied, ranging from 40 to 845 participants. The majority of participants had undergone surgery for hip fracture, joint arthroplasty, radical hysterectomy, bowel cancer, or burch colposuspension, while the remaining participants had benign prostatic hyperplasia or were stroke patients. The mean age of the participants ranged from 46 to 80 years. Four out of eight studies included both males and females [6,16,17,18], whereas three studies exclusively involved females [6,16,17,18,19,20], and one study examined males only [22].

Six of the studies compared the efficacy of bladder training through clamping indwelling urinary catheters versus free draining [6,16,17,18,19,20]. In contrast, one study compared clamping with no clamping, along with simultaneous pharmacological treatment in both groups [22], while another study compared different clamping times on day 1 versus day 3 postoperatively [21]. The number of participants in each study varied, with a minimum of 20 and a maximum of 440 participants. The shortest mean duration of indwelling urinary catheter use was 2 days, and the longest was 37.3 days. Two of the included studies reported that catheter removal time was determined based on the physician's decision, occurring between 10 and 14 days after surgery [6,20]. A study formed catheter removal was performed once patients expressed a desire to void [18]. Five studies reported that catheter removal was performed following catheter clamping at varying specific times [16,17,19,21,22].

Participants in the intervention group underwent an intermittent catheter clamping procedure prior to catheter removal that was supposed to simulate normal bladder filling and emptying. The clamping regime was diversely explained in studies. The most described clamping cycle involved 4 hours of clamping (n=4) followed by 5 minutes of drainage (n=3). Some studies utilized shorter durations, such as 3 hours of clamping, or 1 hour and 45 minutes of catheter clamping followed by a release period of either 5 or 15 minutes [16,19,21]. Another study used progressively increasing clamping durations, ranging from 1 hour to 4 hours, with 5 minutes of drainage each time over a 6-day period [6]. The shortest intervention duration was 9 hours and 10 minutes, while the longest was 7 days. Most studies repeated the clamping cycle throughout the 24 hours (n=6), whereas one study implemented daytime clamping only and free drainage at night [20], another using daytime clamping for the first 5 days, followed by full-day clamping on the final day of the intervention [6]. Catheter monitoring and clamping were performed by nurses (n = 7), while Gong et al. (2017) instructed patients on the procedure, allowing them to adhere to the clamping scheduled independently [6].

Quality assessment

The quality of studies was assessed using Cochrane Risk of Bias 2.0 (RoB 2.0).

Regarding the overall quality of the included studies, 62.5% of the studies had some

concerns in the risk of bias, 25.0% of the studies had a low risk of bias, and 12.5% of the studies had a high risk of bias. Four studies had some concerns in randomization processes and intended interventions. Two studies had some concerns in selections of the reported result (Figure 2).

Pooled results

The mean change in outcomes from baseline to posttest was calculated, and the differences between the experimental and control groups were estimated. The pooled results for all outcomes are presented in Table 2. For all outcomes, forest plots are presented in Figure 3a–d.

Effect of clamping urethral catheter on urinary tract infections

The pooled effect for the 4 studies on UTI had no significant difference between the bladder training group and the control group (RR=1.10; 95% CI 0.77 to 1.56; p=0.60, Figure 3a). The studies had no heterogeneity (I^2 = 0, p =0.43, Figure 3a). The results of the Egger's test indicated publication bias (p = 0.007). However, after adjustment using the trim and fill method, the results revealed a smaller and statistically significant effect size (Hedges' g = −0.21,95%CI: −0.409 to −0.017).

Effect of clamping urethral catheter on re-catheterization

The pooled analysis of four studies investigating re-catheterization suggested that clamping the urinary catheter did not significantly minimize the probability of re-catheterization compared to the drainage group (RR = 0.85; 95% CI 0.53 to 1.37; *p* = 0.50, Figure 3a). The results of the Egger's test indicated publication bias (p = 0.007). However, after adjustment using the trim and fill method, the results revealed a smaller and statistically significant effect size (Hedges' g = −0.21,95%CI: −0.409 to −0.017).

Effect of clamping urethral catheter on first voiding volume

The pooled analysis of three studies investigating first voiding volume suggested that clamping the urinary catheter did not significantly minimize the probability of first voiding volume compared to the drainage group (MD = -5.28; *p* = 0.12, Figure 3c). The results of the Egger's test indicated publication bias (*p* = 0.03).

Effect of clamping urethral catheter on time to first voiding.

The aggregated analysis indicated that IUC clamping before removal did not offer significant advantages over unclamping in diminishing the time to first voiding (MD=-0.16; p=0.52, Figure 3d). The results of the Egger's test indicated non-publication bias (*p* = 0.816).

DISCUSSION

Our review highlights the variability in bladder training protocols that have been implemented yet remain unvalidated through randomized controlled trials (RCTs) designed to assess the effectiveness of bladder exercises on various outcomes. This study specifically examined the role of clamping in relation to the incidence of urinary tract infections, time to first voiding, first voiding volume, and re-catheterization rates. The meta-analysis revealed no statistically significant differences in the effectiveness of clamping.

The research results indicate that the risk of CAUTIs is not significantly different between the clamping and the control group. These findings are consistent with previous meta-analyses [11,19]. In contrast, a recent report suggested that catheter clamping may increase the risk of UTI in patients with catheterization durations of ≤7 days, with no difference in risk observed compared to those with catheterization durations of >7 days [7]. A Cochrane meta-analysis found uncertainty about whether catheter clamping, or free drainage affects the risk of CAUTIs, largely due to the low quality of the available evidence [11]. In addition to factors such as the technique used for catheter insertion and the management of closed drainage systems, the length of time a catheter remains in place is a key modifiable risk factor influencing the likelihood of developing a urinary tract infection after catheterization. Research has shown that the risk of CAUTI increases by 3% to 7% with each additional day the catheter is retained [12]. The probability of developing a urinary tract infection rises significantly for patients with catheters left in for more than six days, and infection is almost certain if the catheter remains for over 30 days [24]. Catheter clamping

may prolong the indwelling catheter time, as described in some interventional procedures [16,18,19]. However, some studies alternatively approached by early determination of catheter removal time and clamping was performed before the scheduled removal, showing that the actual catheter indwelling time remains unchanged [6,21,22]. Hence, regular monitoring of the catheter condition and early assessment of the possibility of catheter removal are essential. Furthermore, establishing a bladder recondition program before removal, accompanied by clear implementation guidelines, should be done prior to evaluating its effectiveness.

We found no statistically significant relationship between the time to first voiding and the first void volume in the clamping group. A previous reported a longer hour to first voiding in the interventional group [7]. This finding also indicated that catheter clamping did not prove effective in reducing the need for re-catheterization, which aligns with findings from previous studies [11,12,23]. Proper urination depends on the coordinated action of the bladder muscles and the urethral sphincter, all regulated by the central nervous system. Any disruption to this coordination can result in urinary retention, which is characterized by the inability to pass urine or to avoid a sufficient amount. The underlying causes of urinary retention include blockages that most commonly due to benign prostatic hyperplasia as well as inflammation, certain medications, and neurological disorders [25]. The mean aged of participants was over 45 years and the majority had undergone surgical procedures, both of which are factors that may increase the likelihood of urinary retention, especially when combined with continuous urinary catheterization. In contrast, bladder training which involves intermittent clamping of the catheter followed by emptying is primarily intended to retrain the bladder muscles and help restore a normal pattern of urination. Generally, bladder training is defined as a technique that gradually extends the intervals between voiding [26]. However, only one included study utilized a technique involving progressively clamping [6]. Modifying the bladder's function in the short term may produce the contrary effect. Moreover, evaluating voiding efficiency requires systematic measurement of voiding time, urine volume, and residual urine volume, involving recording the properties of subsequent voids with the same measurements. A previous study showed the essential importance of patient engagement, motivation, and awareness, especially in understanding bladder function and recognizing the urge to urinate for achieving successful intervention outcomes. [26,27]. In addition to interventions targeting the restoration of muscle activity involved in the urination mechanism, the volume of urine produced in the bladder must also be considered. Ma et al., (2023) suggested that, with a limited volume of urine in the bladder, internal pressure is autonomously regulated, which could potentially result in disruptions to bladder rhythm [6]. Urine output can be affected by factors such as dietary, fluid consumption, and disease conditions. However, only one study by Sun et al., provided instructions to patients regarding compliance with fluid intake during the intervention [21]. Further intervention studies are needed that include standardized clamping training, patient participation, the utilization of comprehensive assessment variables, and consideration of factors influencing urine output, to provide additional evidence on the role of clamping.

Strength and limitations

This meta-analysis conducted searches of seven databases; as a result, we included 8 RCTs that evaluated various outcomes. However, this meta-analysis has several limitations. First, publication bias was detected in several outcomes. Nevertheless, all effect sizes remained significant after adjustment with the trim-and-fill method. Second, we did not include articles published in languages other than English, which may have created a language bias. Third, one study were judged to have a high risk of bias, and six studies were judged to have some risk of bias. Therefore, these results should be interpreted with caution.

Future Research Recommendations

The effectiveness of clamping for bladder recovery after catheter removal remains unproven, with no significant adverse events reported. Further studies should use standardized clamping protocols, greater patient engagement, and multidimensional outcome assessments

CONCLUSION

Clamping before catheter removal in IUC patients has non beneficial effects on the risk of urinary tract

infections, time to first urination, first void volume, and catheter re-insertion. The results were highlighted the need for further validation of intervention programs through well-designed RCTs.

Source of funds: This research received no specific grant from any funding agency in the public, commercial, or nonprofit sectors.

Conflict of Interest: All authors declared that they have no conflict of interest.

Ethical clearance: We registered for the meta-analytic review at PROSPERO (CRD42023401956).

Author's contribution.

Data gathering and idea owner of this study: P.V.T

Study design: P.V.T, N.M.N, B.T.L, & P.T.N.A

Data gathering: P.V.T, N.M.N, B.T.L, & P.T.N.A

Writing and submitting manuscript: P.V.T & P.T.N.A

Editing and approval of final draft: P.V.T

Table 1. Characteristics of included studies

STT	Author/country	Disease	Sample size/ Arm/n		Mean age		% male		Clamping schedule		Indwelling urinary catheter duration	Removal time	Outcome measure	Main findings
			IG	CG	IG	CG	IG	CG	Control group	Intervention group				
1	Zhengyong et al., 2014/ China	Benign prostatic hyperplasia	440	405	66 (55-92)	66 (55-90)	100	100	pharmacological treatment (tamsulosin 0.2 mg and finasteride 5 mg once daily) with free drainage	pharmacological treatment combined with bladder training by clamping for 4 h followed by 5 min of urinary drainage, a cycle repeated over 24 hrs for 7 days Clamping was performed in IG immediately after the first drained urine volume was collected using two-way Foley catheter	7 days	After 7 days, trial without catheter (TWOC) was performed	Time to first voiding, first voided volume, postvoiding residual volume (PVR), mean void volume, intravesical prostatic protrusion (IPP), TWOC success rates, Incidence of urinary tract infection, subjective complaints, other complications	The overall success rate of TWOC was 66.9%. TWOC was successful in 65.2% of cases in the intervention group and 68.6% in the control group. **There was no statistically significant difference** in TWOC success rate, the mean time to first voiding, volumes at first void, PVR, incidence of related complications and adverse events between the two groups ($p > 0.05$)
2	Nyman et al.,2010/ Sweden	Hip fracture	55	58	79 (11.0)	80 (11.2)	29	26	No clamping, free drainage	Clamping at 6 AM on postoperative day 2 until they needed to urinate, the catheter was removed clamped, every 4 hours, patients were provided bladder scan and had re-catheterization if bladder volume exceeded 450ml and patient were unable to urinate	2 days	Patients desire to void	The amount of time to return to normal bladder function, re-catheterization, length of hospitalization	The median time required to return to normal bladder function was six hours in the clamped catheter group and four hours in the free drainage group. **There were no significant differences between the groups** regarding the time required to regain normal bladder function ($p = 0.156$), the number of patients requiring re-catheterization ($p = 0.904$) and the mean time in hospital ($p = 0.777$)

STT	Author/country	Disease	Sample size/ Arm/n		Mean age		% male		Clamping schedule		Indwelling urinary catheter duration	Removal time	Outcome measure	Main findings
			IG	CG	IG	CG	IG	CG	Control group	Intervention group				
3	Markopoulos et al.,2019/ Greece	Total joint arthroplasty	114	104	69 (8.7)	69.8 (7.3)	46.5	50	No clamping, free drainage	Clamping at 8 AM on postoperative day 2 for 3 hours and clamping for 5 mins, repeated this procedure 3 times for a total of 9 hours clamping and 10 mins releasing. The patient was re-catheterization if they failed to urinate within 10 mins	2 days	The catheter was removed after 9 hours and 10 mins of clamping procedure	Re-catheterization, occurrence of symptomatic urinary tract infection	Three cases of re-catheterization in the bladder training group (2.6%) and six in the free drainage removal group (5.8%). **The difference between the groups was not statistically significant. There were no symptoms of pain and suspected urinary tract infection.**
4	Gong et al., 2017/ China	Radical hysterectomy	70	128	46.14 (8.33)	45.7 (9.63)	0	0	No clamping, free drainage	Patients were educated how to clamp the IUC and provided designed training sheet to finish. IUC was clamped for 4 hours followed by 5 mins of drainage when patients had urination desire. The cycle repeated in the daytime for 2 days before IUC removal	10-14 days	10-14 days depending on preference and experiences of the surgeons	The rate of re-catheterization, residual urine volume (RUV) 24 hrs after removal, incidence of urinary tract infection (UTI) and duration of re-catheterization.	Ten patients in the clamping group and 19 in the control group underwent re-catheterization, the incidence of which showed no significant difference (14.3% vs 14.8%). The incidence of UTI (22.9% vs 20.3%) had no significant differences between the two groups. The days of re-catheterization were not statistically different between the two groups (11.40 ± 6.75 vs 9.42 ± 5.23). *However, the RUV 24 hrs after removal was higher in the clamping group than that in the control group.*
5	Oberst et al.,1981/ USA	Cancer of bowel	**52**	**58**	64.5 (10.2)	59 (11.92)	47	53	Straight gravity drainage	Clamping started on 4th day of post operation with the increasing period from 1-hour to maximum 4-hour interval at day 6 of clamping schedule. A 5 min drainage interval followed each clamping period throughout the study. In the first 5 day of clamping, the catheter was freely drain at night, only clamping continued for 24 hours on the final day.	10 days	#10 days based on physician's advice	Re-catheterization, time to first voiding, first voided volume	In the straight drainage group the mean time to first voiding is 325 minutes, significantly longer than the clamping group mean of 207 minutes ($p< 0.005$)

STT	Author/country	Disease	Sample size/ Arm/n		Mean age		% male		Clamping schedule		Indwelling urinary catheter duration	Removal time	Outcome measure	Main findings
			IG	CG	IG	CG	IG	CG	Control group	Intervention group				
6	Fanfani et al., 2015/ Italya	Radical hysterectomy	55	56	52	50	0	0	No clamping, free drainage	On postoperative day 3, clamping for 3 hours followed by 15 mins drainage within 24 hours.	3 days	Postoperative day 4	Rate of clean intermittent self-catheterization (ISC)	Rate of ISC was not different between bladder training and control groups (20.0 and 19.6%, respectively), p=0.962
7	Moon et al., 2012/ Korea	Stroke patient	20	20	59 (14)	66 (14)	50	50	No clamping, free drainage	Clamped 4 hrs followed by 5 mins drainage over 24hrs (group 1) and over 72 hours (group 2)	**7.3 (4.2) days**		Time to first voiding (FV), first voided volume (FV-vol), residual urine volume after FV, mean void volume, and residual urine volume on the third day after IUC removal, voiding method, incidence of urinary tract infection, subjective complaints, other complications	Time to FV, FV-vol, residual urine volume after FV, voiding method, mean voided volume, and residual urine volume on the third day after IUC removal had **no significant difference** among the 0-day and the 1-day clamping groups. The number of patients having symptomatic urinary tract infection among CG and 1-day clamping IG were 0 and 1, respectively. Strong negative correlation between age and FV-vol after IUC removal in the 0-day and other clamping groups (r = 0.74, P = 0.002 and r = 0.4, P = 0.05)
8	Sun et al., 2004/ Taiwan	Burch colposuspension	42	43	46.7 (6.7)	48.3 (8.3)	0	0	Clamping on day 3 postoperative, from 9 A.M to 9 P.M by clamping the catheter for 1 h 45 mins and unclamping the catheter for 15 mins, repeated the schedule for 2 days	Clamping on day 1 postoperative, from 9 A.M to 9 P.M by clamping the catheter for 1 h 45 mins and unclamping the catheter for 15 mins, repeating the schedule for 2 days	3 days (IG) 5 days (CG)	The catheter was removed after a 2-day bladder training program for both groups	Immediate voiding difficulties, urinary tract infection rate	There was no statistical difference between intervention and control groups regarding the percentages of immediate voiding difficulties (7.1% vs 0%, respectively, P >0.05) and the postoperative urinary tract infection rates (16.6% vs 23.3%, respectively, P >0.05)

Table 2. Risk ratio/ Difference in means for different outcomes of clamping

Item	Number of studies	Risk ratio/ Difference in means	95% CI	*p*	
UTI	4	1.1	0.77 to 1.56	0.6	
Re-Catheterization	4	0.85	0.53 to 1.37	0.5	
First voiding volume	3	-5.38	-11.85 to 1.3	0.12	
Time to first voiding	4	-0.16	-0.48 to 0.28	0.61	

Noted: 95% CI, 95% Confidence interval; UTI, Urinary tract infections

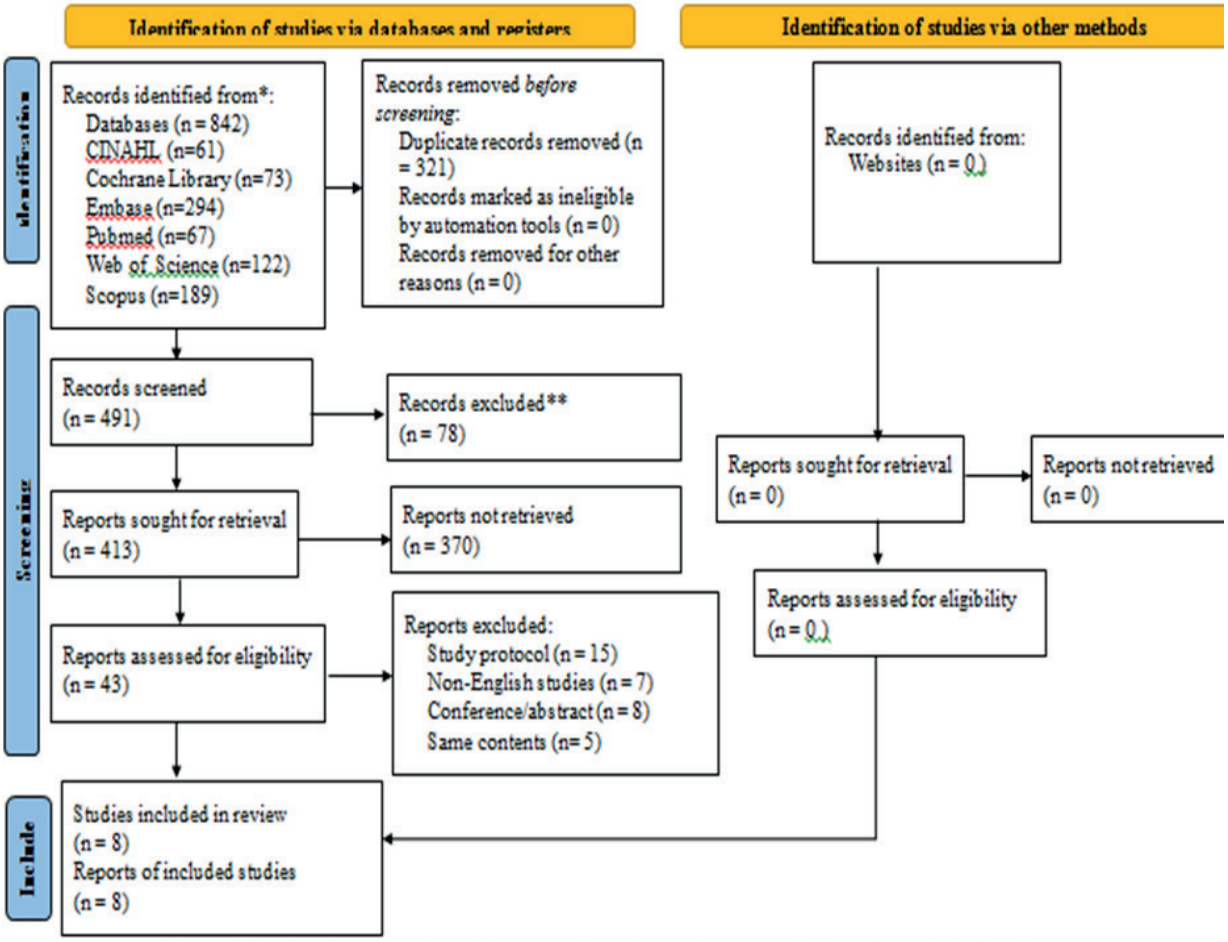


Figure 1. *Preferred reporting items for systematic and meta-analyses (PRISMA) 2020 flow diagram*

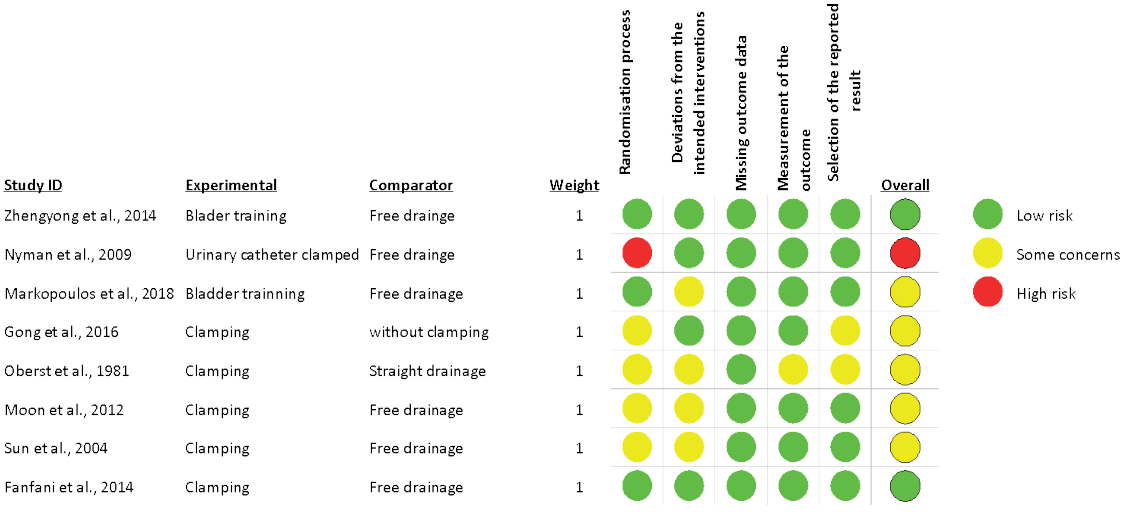
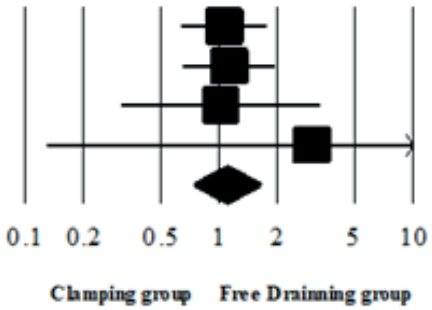


Figure 2. *Risk of Bias in Each Included Study*

a. Urinary tract infection

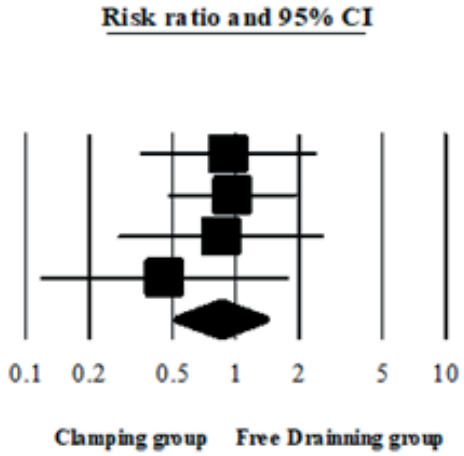
Study name	Risk ratio	Lower limit	Upper limit	p-Value	Events / Total IG	Events / Total CG
Zhengyong et al., 2014	1.06	0.64	1.76	0.82	30 / 440	26 / 405
Gong et al.,2016	1.13	0.65	1.95	0.67	16 / 70	26 / 128
Fanfani et al., 2013	1.02	0.31	3.32	0.98	5 / 55	5 / 56
Moon et al., 2012	3.00	0.13	69.52	0.49	1 / 20	0 / 20
	1.10	0.77	1.56	0.60	52 / 585	57 / 609



Test for heterogeneity $I^2 = 0$ (p=0.43)

b. Re-Catheterization

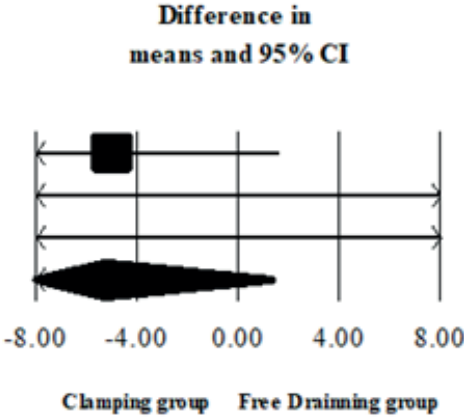
Study name	Risk ratio	Lower limit	Upper limit	p-Value	Events / Total IG	Events / Total CG
Zhengyong et al., 2014	0.92	0.35	2.43	0.87	8 / 440	8 / 405
Gong et al.,2016	0.96	0.47	1.95	0.92	10 / 70	19 / 128
Nyman et al., 2013	0.85	0.27	2.62	0.78	5 / 55	6 / 56
Markopoulos et al., 2012	0.46	0.12	1.78	0.26	3 / 114	6 / 104
	0.85	0.53	1.37	0.50	26 / 679	39 / 693



Test for heterogeneity $I^2 = 0$ (p=0.77)

c. First voiding volume

Study name	Difference in means	Standard error	p-Value	IG	CG
Zhengyong et al, 2014	-5.00	3.38	0.14	287	278
Moon et al., 2012a	-18.50	29.92	0.54	20	20
Moon et al., 2012b	-33.70	54.50	0.54	20	20
	-5.28	3.36	0.12	327	318



Test for heterogeneity $I^2 = 0$ (p=0.96)

d. Time to first voiding

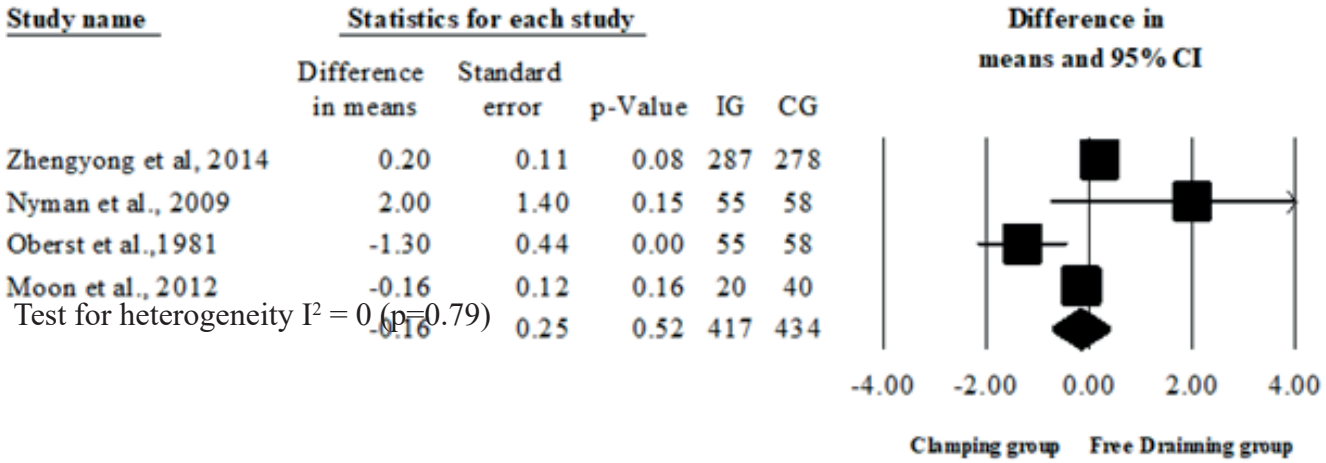


Figure 3. Forest plot of risk ration or difference in means of clamping

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