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Need to clamp indwelling urinary catheters before removal after different durations: a systematic review and meta-analysis

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ABSTRACT

Objective This meta-analysis aimed to evaluate the effect of bladder training by clamping on bladder urethral function in patients with indwelling urinary catheters used for different durations.

Design Systematic review and meta-analysis.

Data sources The UpToDate, Cochrane Library, OVID, PubMed, China National Knowledge Infrastructure, CINAHL and Embase were screened from 1 January 2000 to 28 February 2022.

Eligibility criteria for selecting studies Randomised controlled trials (RCTs) or quasi-experimental designs comparing the efficacy of bladder training in patients with an indwelling urinary catheter by clamping or free drainage before urinary catheter removal were published in English or Chinese.

Data extraction and synthesis Two reviewers independently extracted the data and assessed the quality of studies. Continuous variables were analysed using mean difference and standardised mean difference (SMD) values with a 95% CI. Categorical variables were analysed using relative risk (RR) and 95% CI.

Primary and secondary outcome measures The primary outcome was urinary tract infection incidence, and secondary outcomes included hours to first voiding, incidence of urinary retention and recatheterisation and residual urine volume.

Results Seventeen papers (15 RCTs and 2 quasi-RCTs) comprising 3908 participants were included in the meta-analysis. The pooled results of the meta-analysis showed that the clamping group had a significantly higher risk of urinary tract infections (RR=1.47; 95% CI 1.26 to 1.72; p<0.00001) and a longer hour to first void (SMD=0.19; 95% CI 0.08 to 0.29; p=0.0004) compared with the free drainage group. Subgroup analysis of indwelling urinary catheter use durations of ≤7 days indicated that clamping significantly increased the risk of urinary tract infection (RR=1.69; 95% CI 1.42 to 2.02, p<0.00001) and lengthens the interval to first void (SMD=0.26, 95% CI 0.11 to 0.41, p=0.0008) compared with free drainage.

Conclusions Bladder training by clamping indwelling urinary catheters increases the incidence of urinary tract infection and lengthens the hours to first void in patients with indwelling urinary catheters use durations of ≤7 days compared with the free drainage. However, the effect of clamping training on patients with an indwelling urinary catheter use duration of >7 days is unclear.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This systematic review included a relatively large number of studies and objective outcomes to evaluate the effects of clamp training.
- ⇒ Unlike past reviews, subgroup analysis was conducted based on the duration of indwelling urinary catheter use according to clinical practice.
- ⇒ Sensitivity analysis was conducted and partially accounted for statistical heterogeneity; however, several factors associated with heterogeneity remained unclear.
- ⇒ The number of studies with an indwelling urinary catheter use duration of >7 days was small, and test efficacy was limited.

INTRODUCTION

Indwelling catheters are frequently used in clinical settings, with catheterisation rates ranging from 12% to 77%.[1] They have been largely used to address chronic urinary retention and bladder obstruction, prevent intraoperative bladder dilation and incontinence and record urine volume.[2 3] When indwelling urinary catheters are used, the bladder is constantly voiding with continuous urine drainage. Bladder tension is weakened, making patients being highly susceptible to catheter-associated infections, urinary retention and other postremoval complications.[4 5] In 1936, to reduce the incidence of bladder dysfunction after removal, Ross proposed performing bladder training by clamping before catheter removal to theoretically prevent postremoval bladder dysfunction by stimulating the bladder detrusor muscles to simulate bladder filling and emptying during normal voiding.[6] Clamping training is considered behavioural therapy, and a study by Oberst[7] showed that bladder training by clamping can prevent bladder dysfunction after lower abdominal surgery and has been recognised as an effective intervention for bladder dysfunction.

With the rise of accelerated rehabilitation surgery, various studies have concluded that indwelling catheters can be removed as soon as possible postoperatively without bladder training, as most of the study population, which underwent general surgery, had a postoperative indwelling use duration of ≤7 days.[8] It has been argued that not only is clamping not conducive to observing the colour and nature of the urine in time, but it is also often accompanied by artificial urethral injury and overfilled bladder caused by the untimely opening of the catheter during clamping.[9] Accordingly, from 2016 to 2021, several systematic reviews analysed the need to clamp urinary catheters in patients with short-term indwelling urinary catheters (use duration, ≤14 days), though the results were inconsistent.[10–14] Wang *et al* revealed that clamp training reduced the risk of urinary retention and ureteral recatheterisation dysuria but did not report the outcome of urinary tract infection (UTI).[11] In contrast, Wang and Fernandez reported an important outcome pertaining to UTI, which was that it was not significantly different between the clamped catheter and free drainage groups.[10 15] All three of these studies did not evaluate the body of evidence associated with their results. The long-term use of indwelling catheters may be permanent in some patients. Patients with long-term indwelling urinary catheters have more complex factors influencing infection and a greater need for bladder exercise than those with short-term indwelling urinary catheters.[16] Studies have shown that the incidence of catheter-associated UTIs increases by 5%–8% for each additional day during which a catheter is left in place.[17] The British Association of Urological Surgeons and Nurses[18] consensus for long-term indwelling urinary catheters (use duration ≥28 days) is that bladder training can increase bladder volume and reduce the loss of bladder compliance and occurrence of urinary tract blockage. However, this conclusion was derived from an assumed in vitro human bladder model. Chinese experts and scholars do not recommend bladder training by clamping urinary catheters in patients with long-term indwelling urinary catheters for a duration of ≥14 days.[19]

Although catheter placement, care and removal are part of the nursing staff's job, the choice of removal time and clamping training depends on the physician's preference. Moreover, there is no consensus on the cut-off values for the usage duration of short-term and long-term indwelling urinary catheters. The effectiveness of bladder training is controversial in patients with different indwelling times. Therefore, our systematic review stratified the different durations of indwelling urinary catheter use according to the included randomised controlled and quasi-experimental trials. This study aimed to bridge the gap between relevant systematic reviews and provide evidence for clinical practice by comparing the effect of clamping with free drainage on objective outcomes among patients with different usage durations of indwelling urinary catheters.

METHODS

Search strategy

This meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.[20] Two authors conducted a comprehensive literature search of articles published in English or Chinese in the UpToDate, Cochrane Library, OVID, PubMed, CINAHL and Embase databases. We also searched the China National Knowledge Infrastructure, the world's largest Chinese database. This meta-analysis included randomised controlled trials and quasi-experimental designs published from 1 January 2000 to 28 February 2022. The related grey literature was retrieved and supplemented manually. The electronic search strategy is presented in online supplemental table 1.

Selection criteria

Participants

The target population was adults aged ≥18 years who required indwelling urethral catheterisation in a hospital setting. We excluded patients with catheter placement over the pubic symphysis, intermittent catheterisation, spinal cord or nerve injury affecting the micturition reflex, congenital malformation of the genitourinary system and an unspecified catheter retention time or a retention time <24 hour.

Intervention

Participants in the experimental group underwent clamping indwelling urethral characterisation as the main intervention before removal, followed by immediate clamping without free drainage, until patients felt the urgency of void or clamping and free drainage alternative at fixed intervals.

Comparison

The control group included patients who received standard care or free drainage without other bladder training interventions before urinary catheter removal.

Outcome

The primary outcome was the incidence of UTI, and secondary outcomes included hours to first voiding, incidence of urinary retention and recatheterisation and residual urine volume. UTI was defined as bacteriuria accompanying fever, frequent or painful urination and a burning sensation during urination without other foci of infection and was evaluated using subjective symptoms or laboratory results, including pain, discomfort and burning on micturition.[18]

Data extraction

Data were independently extracted by two authors using a predesigned data extraction sheet in Microsoft Excel.

The extracted data comprised study characteristics (name of the first author, publication year and country), patient characteristics (sex, sample size and type of disease), intervention characteristics (use duration of indwelling urinary catheter and removal time) and outcome indicators. If data were missing, we attempted to contact the authors. In trials reporting mean values without SDs but with p values or 95% CI, we performed data conversion using an Excel sheet. In case of disagreement, we consulted a third reviewer.

Quality assessment

The authenticity assessment of randomised controlled trials (RCTs) was independently completed by two researchers according to the Cochrane Handbook for Systematic Reviews of Interventions.[21] A judgement of a low, high or unclear risk of bias was made for each item. If the study fully met the used criteria, the likelihood of bias was low, and the quality grade was A. If the criteria were partially met, the likelihood of bias was moderate, and the quality grade was B. If the criteria were not met at all, the likelihood of bias was high, and the quality grade was C. In case of dispute, a third review panel member was consulted. The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system was used to comprehensively evaluate the quality of the evidence considering efficacy and risk of bias.

Statistical analysis

Review Manager V.5.4.1 software (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2012) was used for data analysis. All continuous variables were pooled using the mean difference (MD) and standardised mean difference (SMD) with 95% CIs. For dichotomous outcomes, the number of outcomes was pooled to calculate the risk ratio (RR) with 95% CIs. A descriptive analysis was used for ordered outcome data (residual urine volume) according to the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions.[21] The I^2 statistic and p value for heterogeneity were used to assess statistical heterogeneity. Heterogeneity was considered unimportant when I^2 was between 0% and 40%, moderate when I^2 was between 30% and 60%, substantial when I^2 was between 50% and 90% and considerable when I^2 was between 75% and 100%.[21] If I^2 was ≤60% or p value was >0.1, the study was categorised as mildly statistically heterogeneous, and the use of a fixed effect model was analysed. Otherwise, the effect size was pooled using a random-effects model if heterogeneity could not be explained and I^2 was >60% or p value was ≤0.1.[21] Furthermore, a sensitivity analysis was conducted to explore the potential sources of heterogeneity and stability of the results using STATA software (V.17.0; Stata Corp, College Station, Texas). In the sensitivity analysis, the leave-one-out approach was used to judge the changes in the effect estimate of the meta-analysis after removing one trial. Susceptibility of the results of the meta-analysis to significant alteration after removing studies was considered to indicate a lack of robustness in results. Publication bias was evaluated based on the symmetry of funnel plots.

Subgroups analysis

A predefined subgroup analysis stratified participants according to the duration of indwelling urinary catheter use, with 7 days used as the cut-off value. In America and China, short-term indwelling urethral catheters were defined as those used for a duration of <14 days. However, the British Association of Urological Surgeons and Nurses Consensus Document defined it as <28 days. We found that the duration of indwelling ureteral catheter use was defined differently between trials.[22] Moreover, an increasing number of specialists recommend indwelling catheters to be used for the shortest time possible to avoid complications. In current studies, most catheters that need to be indwelled for surgery are removed 1 week postoperatively.[23]

Patient and public involvement

Patients and the public were not involved in this study.

RESULTS

Study selection

A total of 4993 studies were obtained from the database search, while 12 studies were obtained from the references of the included studies. Seventeen studies were included in this review (15 RCTs and two quasi-experimental studies). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were used to generate a flowchart of the screening process (figure 1).

Study characteristics

Seventeen studies involving 3908 patients were included in the meta-analysis. Sixteen studies comprised postoperative patients, while one[24] included poststroke patients. Regarding the languages of the included studies, 10 studies[9 25–33] were reported in Chinese, and seven studies[24 34–39] were reported in English. The duration of indwelling catheter use was >7 days in four studies[24 25 34 35] and ≤7 days in 13 studies.[9 26–33 36–39] As for removal time, four studies reported that indwelling urinary catheters were removed according to the doctors' discretion,[9 27 29 31] five[25 26 32 33 37] reported that the catheters were removed when patients felt the urge to urinate and eight[24 28 30 34–36 38 39] reported that they were removed at a specific time point. Patient characteristics are presented in table 1.

Risk of bias in the included studies

The methodological quality of the 17 included studies was B. Thirteen studies[9 25–34 36 37] described random sequence generation and four studies[24 35 38 39] described allocation concealment. All 17 studies reported outcomes with comparable baseline values. Owing to the specificity of the intervention, it was not possible to completely blind the study participants and caregivers. However, the

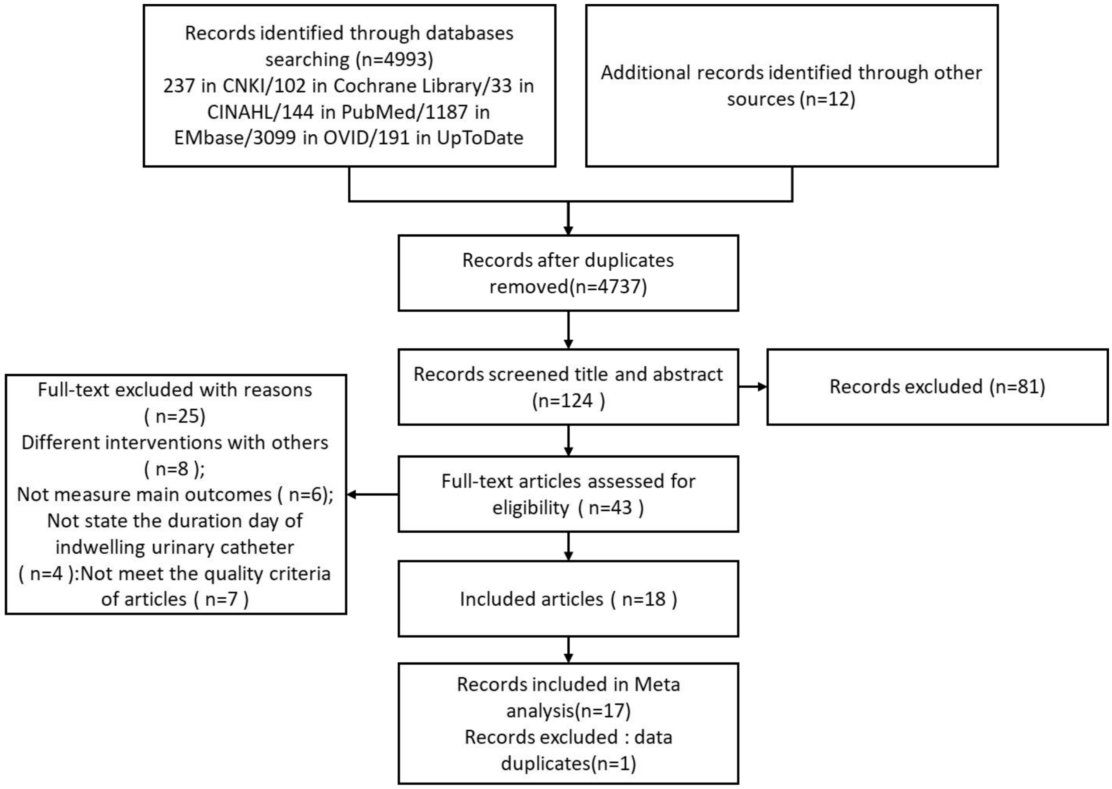

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart of the study inclusion process.

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart of the study inclusion process.

selected outcome indicators were more objective; therefore, bias in blinding was defined as uncertain in most studies. The results of the methodological quality are shown in figure 2.

Effect of clamping urethral catheter comparing free drainage

Primary outcome

Incidence of UTI

Ten studies[9,24–26,28,30,33–35,38] (N=2407) that reported UTI outcomes were included in the meta-analysis. A fixed-effects model was used with moderate heterogeneity (I^2=51%; p=0.04). The pooled results of the two durations of indwelling urinary catheters suggested that clamping urinary catheters significantly increased the incidence of UTI compared with free drainage (RR=1.47; 95% CI 1.26 to 1.72; p<0.00001). In the subgroup analysis, moderate heterogeneity was detected for durations of ≤7 days (I^2=44%; p=0.13). Free drainage significantly reduced the incidence of UTI compared with clamping (RR=1.69; 95% CI 1.42 to 2.02; p<0.00001) for a usage duration of ≤7 days. There was no significant difference in the incidence of UTI (RR=1.07; 95% CI 0.77 to 1.50; p=0.68) when clamping was compared with free drainage for durations of >7 days. No significant heterogeneity was observed (I^2=0%, p=0.67; figure 3).

Secondary outcomes

Hours to first void

Thirteen studies[9,24–32,35–37] reported this outcome indicator, while two studies used median and quartiles that cannot be converted to mean and standardised deviation through formulas[28,37] as they may not conform to a normal distribution. Hence, 11 studies[9,24,26–29,32,36] (n=2685) were included in the meta-analysis, which suggested that there was a significant difference in the overall effects (SMD=0.09; 95% CI 0.01 to 0.17; p=0.02). However, high heterogeneity was observed (I^2=90%; p<0.00001; figure 4a). Subsequently, a sensitivity analysis was conducted for the outcome of the hours to first void using the leave-one-out approach. We excluded six trials considering the results of the sensitivity analysis and methodological heterogeneity. Among the trials, three studies[9,32,36] using randomised sequence generation had missing or unclear data, though these studies still showed heterogeneity (I^2=64%; p=0.007; figure 4b). Three other studies[27,30,31] using different methods of catheter removal were excluded. Heterogeneity dropped from 64% to 0% for durations of ≤7 days (p=0.78). Heterogeneity between subgroups was 36.5% (p=0.21). The combined results (two durations of indwelling urinary catheters) suggested that free drainage had a significant advantage over clamping in reducing the hours to first void (SMD=0.19; 95% CI 0.08 to 0.29; p=0.0004). The clamping group significantly lengthened the hours to first drainage compared with the free drainage group in a subgroup of patients with durations of ≤7 days (SMD=0.26; 95% CI 0.11 to 0.41; p=0.0008). However, three reports studying a duration of >7 days showed no significant difference (SMD=0.12; 95% CI −0.02 to 0.27; p=0.09) (figure 4c) (figure 5).

Table 1 Characteristics of included studies (N=17)

Author, publication year	Country	Sex (M/F)	Sample size (eg,/CG)	Procedure	Indwelling urinary catheter duration, days/hours	Removal time	Outcome
Hu XY 2013[26]	China	193/141	188/146	General surgery	52.75±25.18 (h) 51.50±26.20 (h)	After two clamping training and patients with a desire to urine	②③④
Ma H 2016[29]	China	182/178	180/180	General anaesthesia surgery	1–3 (d)	Stop clamp training according to the doctor's advice	④
Moon 2012[24]	Korea	30/30	40/20	Stroke	>30 (d)	The 0-day group was removed without clamping. A cycle repeated over 24 hours in the 1-day and over 72 hours in the 3-day clamping group.	③④⑤
Jiang SY 2008[27]	China	164/150	170/144	Orthopaedic surgery	49.86±27.10 (h) 53.63±27.71 (h)	Remove catheters until urine is drained.	②④
Yang JC 2011[32]	China	55/49	51/53	Spine surgery	37.50±14.99 (h) 37.10±15.28 (h)	The catheter was removed when the bladder is full	④
Liu HJ 2013[28]	China	40/177	112/105	Orthopaedic, nail and breast, and gynaecological surgery	26 (24.00–28.65) (h) 24 (22.35–27.83) (h)	IUC was removed from the catheter when the patient felt the urge to urinate after 2–3 times bladder training.	②③
Xu TT 2021[9]	China	216/144	180/180	Thoracic surgery	4 (d)	Stop clamp training according to the doctor's advice	*③④
Chen SZ 2018[25]	China	94/26	60/60	Percutaneous nephrolithotomy	5.8±2.8 (d) 6.0±2.7 (d)	The catheter was removed after the patient felt the urge to urinate	②③④⑤
Zhang X 2020[33]	China	63/55	61/57	Abdominal surgery	47.05±33.144(h) 67±20.603 (h)	The catheter was removed after the patient felt the urge to urinate.	*③
Yan LH 2017[31]	China	132/69	101/100	General surgery	1–7 (d)	The catheter was removed after the patient felt the urge to urinate.	*②④
Yuan ZY 2014[35]	China	845/0	440/405	Benign prostatic hyperplasia	>7 (d)	After the first 7 days of catheterisation	③④⑤
Nie GZ 2015[30]	China	129/88	112/105	Postoperative hip fracture	≤5 (d)	On the second or third postoperative day	*②③④
Liu YS 2013[37]	China	28/51	40/39	Neurosurgery	2.6 (d)	IUDs were removed when the patient felt the need to urinate.	*②⑤
Markopoulos 2018[38]	Greek	105/113	114/104	Total hip and knee replacement	2 (d)	9 hours and 10 min after clamp training	*②③
Gong 2016[34]	China	0/198	70/128	Postoperative cervical cancer	≈14 (d)	On the third postoperative day	②③⑤
Nyman 2010[39]	Sweden	31/82	55/58	Hip fracture	<45 (h)	The catheter was removed in the morning on day 2 after surgery.	②
Büyükyilmaz 2019[36]	Turkey	50/0	28/22	Transurethral prostatectomy	2 (d)	At the third postoperative day	④⑤

*Incidence of urinary retention; ②Rate of re-catheterisation; ③Incidence of urinary tract infection; ④Hours to first void; ⑤Residual urine volume.
CG, the control group; EG, the experimental group

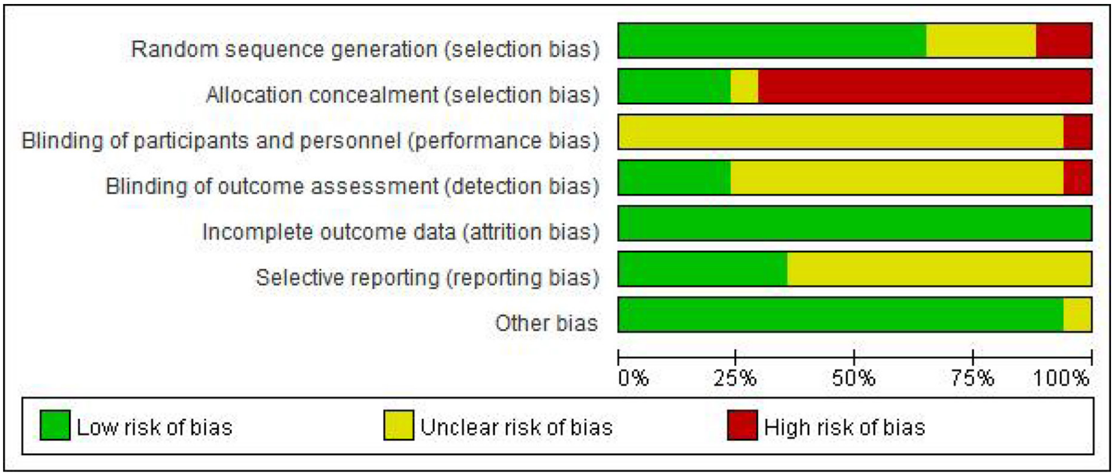

Figure 2 Risk of bias summary.

Incidence of urinary retention

Six studies[9 30 31 33 37 38] (n=1193) reported this outcome indicator. The pooled results suggested that heterogeneity was low when using a fixed-effects model (p=0.32; I^2=14%). Clamped urinary catheters did not show a significant difference in improving urinary retention compared with free drainage (RR=1.13; 95% CI 0.66 to 1.92; p=0.66; figure 6).

Incidence of recatheterisation

Ten studies[25–28 30 31 34 37–39] reported this outcome. A fixed-effects model was used because no heterogeneity was detected (p=0.81, I^2=0%). The aggregated results showed that clamping urinary catheters did not significantly reduce the incidence of recatheterisation compared with the free drainage group (RR=0.78, 95% CI 0.53 to 1.16; p=0.21). The durations of ≤7 days (RR=0.75; 95% CI 0.45 to 1.26; p=0.27) and >7 days (RR=0.83, 95% CI 0.45 to 1.51, p=0.54) did not demonstrate any significant differences when clamping compared with free drainage. The subgroups did not differ significantly (p=0.80; I^2=0%; figure 7).

Residual urine volume after first voiding

Six studies[24 25 34–37] reported this outcome. Three studies[25 34 37] reported this outcome using different definitions of ordered variables and measurement methods. Therefore, we conducted a descriptive analysis. Gong *et al*[34] reported that the residual urine volume after catheter removal in patients with cervical cancer was significantly higher in the clamped group than in the free drainage group (0–50 mL, p=0.003; 50–100 mL, p=0.851; 100–200 mL, p=0.046 and >200 mL, p=0.039). Chen *et al*[25] measured the residual urine volume 24 hours after

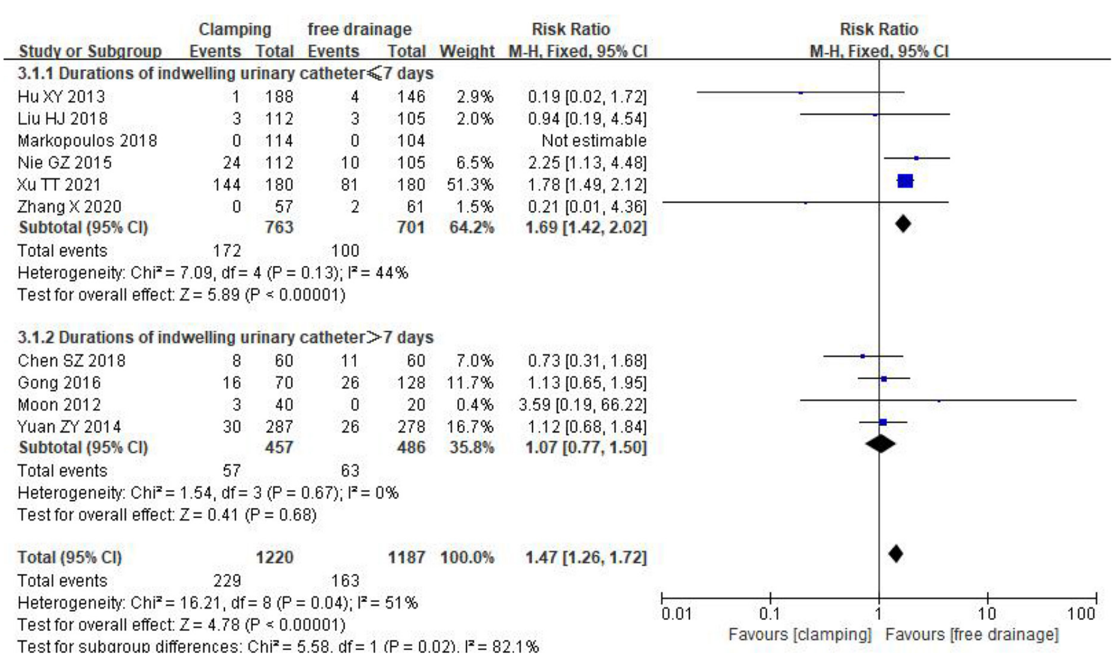

Figure 3 Forest plot of the effect of bladder training by clamping on the incidence of urinary tract infections after catheter removal. M-H, Mantel-Haenszel.

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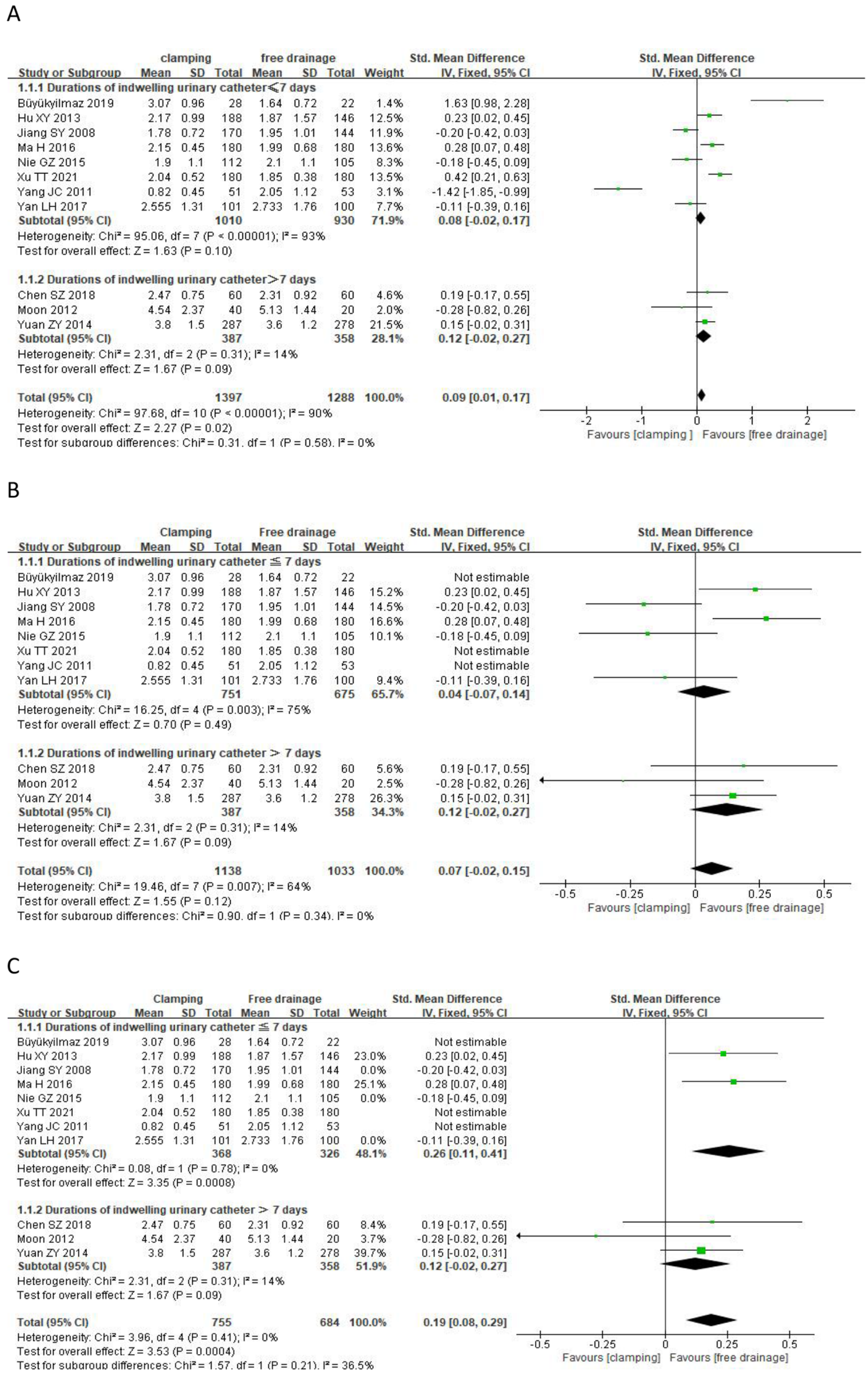

Figure 4 (A) Forest plot of the effect of bladder training by clamping on hours to first voiding after catheter removal; (B) forest plot of the effect of bladder training by clamping on hours to first voiding after catheter removal after exclusion of three studies; (C) forest plot of the effect of bladder training by clamping on hours to first voiding after catheter removal after exclusion of six studies. IV, inverse variance; SMD, standardised mean difference. The unit of the hours to first voiding is an hour.

catheter removal and found no difference between the clamped and free drainage groups. As there was no statistically significant difference, the clamped group was not considered to have a higher volume than that of the drainage group (t=1.370, p=0.087). However, Liu *et al*[37] reported that the residual urine volume after first voiding in postneurosurgical patients was significantly lower in the clamped group than in the free drainage group (p=0.03).

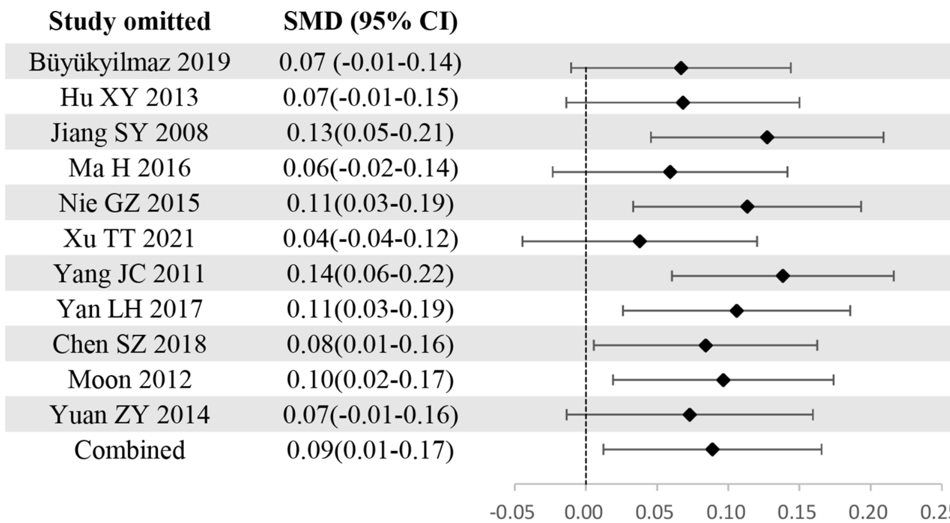

Figure 5 The result of sensitivity analysis for hours to first void.

The other three studies[24 35 36] were pooled for analysis and used continuous variables to report residual urine volume. They immediately measured the residual urine volume after removing indwelling urinary catheters. No heterogeneity was observed (p=0.44; I^2=0%). The pooled result showed that clamping the urinary catheter had no significant effect on improving residual urine volume compared with free drainage (MD=−0.36; 95% CI −4.17 to 3.44; p=0.85). No significant differences were observed among subgroups (p=0.96, I^2=0%) (figure 8).

Certainty of evidence

The results of the GRADE body evidence are presented in online supplemental table 2, including detailed reasons for downgrading in the footnotes. The methodological quality of the included literature was low for the incidence of UTI, hours to first void, residual urine volume and urinary retention because of unclear allocation concealment or randomised sequence generation. Few studies were degraded for high statistical heterogeneity or moderate clinical heterogeneity. Sex, disease and catheterisation type may be potential sources of heterogeneity. No study was degraded for indirectness. The wide CI or limited sample size led to the separate degradation of the evidence quality of residual urine volume and urinary retention. To assess publication bias, we constructed a funnel plot of the primary outcome. The funnel plots for UTI and hours to first void were basically symmetric (figures 9 and 10). Several studies had a large sample size and were concentrated in a narrow area in the upper part of the funnel plot, suggesting that the results were more reliable. There are two reasons for the publication bias. First, it may be inaccurate to assess publication bias because of the small number of included studies. Second, most included studies were Chinese, and positive results are easily published in China.

DISCUSSION

Summary of main results

This meta-analysis included 17 studies with 3908 participants and provided evidence on the effect of clamping urinary catheters on patient bladder function outcomes. We found that clamping urinary catheters significantly increased the incidence of UTI and lengthened the hours to first void in patients with a use duration of ≤7 days. Moreover, there was a significant difference in the pooled duration of catheter clamping.

Effect of clamping on patients with different durations of indwelling urinary catheters

Incidence of UTI

The duration of indwelling catheter use was correlated with the number and types of bacteria causing bacteriuria.

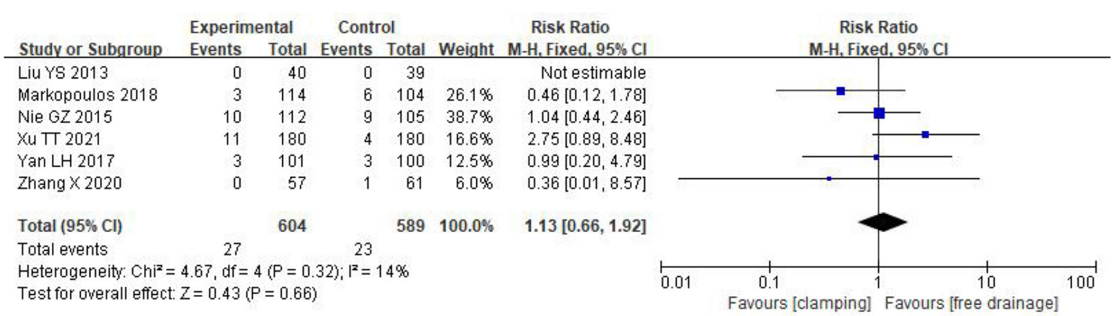

Figure 6 Forest plot of the effect of bladder training by clamping on the rate of urinary retention after catheter removal. IV, inverse variance; M-H, Mantel-Haenszel.

Ma S, *et al. BMJ Open* 2023;**13**:e064075. doi:10.1136/bmjopen-2022-064075

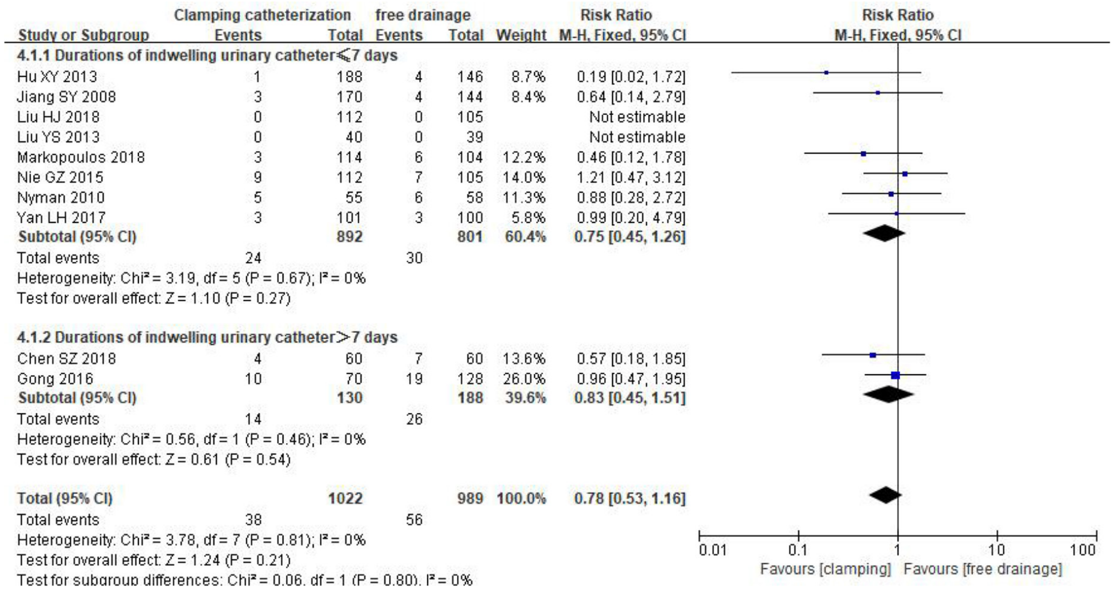

Figure 7 Forest plot of the effect of bladder training by clamping on the incidence of re-catheterisation after catheter removal. M-H, Mantel-Haenszel.

Over time, the risk of developing UTI was 35% after 7 days of catheterisation and 70% after 14 days.[40] The surgical areas of some patients included in the study were close to the bladder and urethra, increasing the chance of bacterial invasion of the lower urinary tract through the skin.[41] Moreover, clamping has been reported to possibly promote the formation of an epithelial or inert surface biofilm in the urinary tract,[42] further increasing the risk of UTI, which is consistent with the results of this study. However, we did not find any significant differences in urinary catheter clamping in patients with UTI for >7 days.

Hours to first void and urinary retention

The normal voiding process involves relaxation of the pelvic muscles and bladder neck and voluntary contraction of detrusor muscles at a frequency of every 3–4 hours.[43] We found that the hours to first void were longer in patients with an indwelling catheter for >7 days than in those with an indwelling catheter <7 days, which suggested that bladder sensation was weakened, possibly due to prolonged catheter indwelling, but clamp training did not seem to increase bladder sensitivity in patients with urinary catheters usage of >7 days. Some studies considered that urinary retention occurred when the patient did not have urine after catheter removal for 10 hours or 24 hours. Hence, we discuss the hours to the first void and urinary retention. The incidence of urinary retention in the clamping group was higher in the included studies than in the general adult male population.[44] Moreover, the male and female sex ratios were 3:2 in this systematic review, which is different from that in the general population. The physiological mechanism of voiding is mild contraction of the detrusor muscles when the bladder is empty and a large stretch of the bladder. When a small amount of urine accumulates in the bladder, the internal pressure of the bladder can be regulated by itself. Therefore, it may be related to the disruption of bladder rhythm or the self-regulatory mechanisms of patients with indwelling urinary catheters as they recover from their disease. We hypothesised that significant anatomical and physiological differences

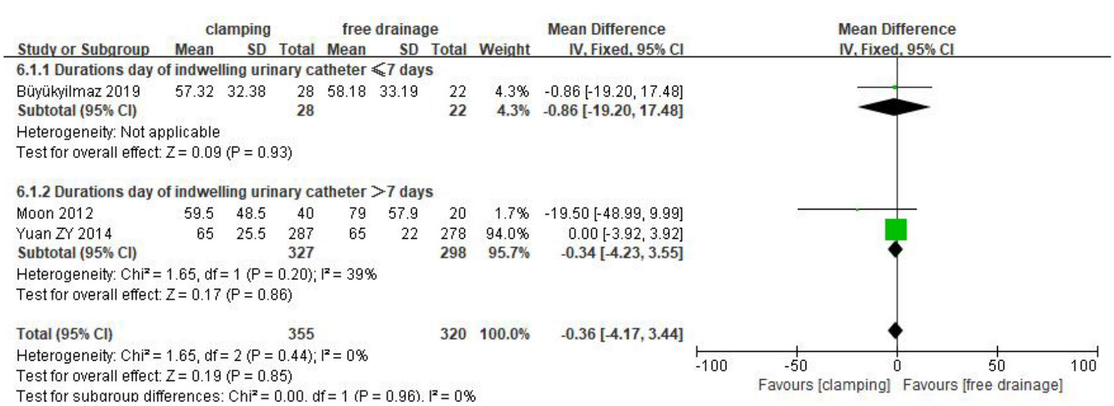

Figure 8 Forest plot of the effect of bladder training by clamping on residual urine volume after first voiding. IV, inverse variance.

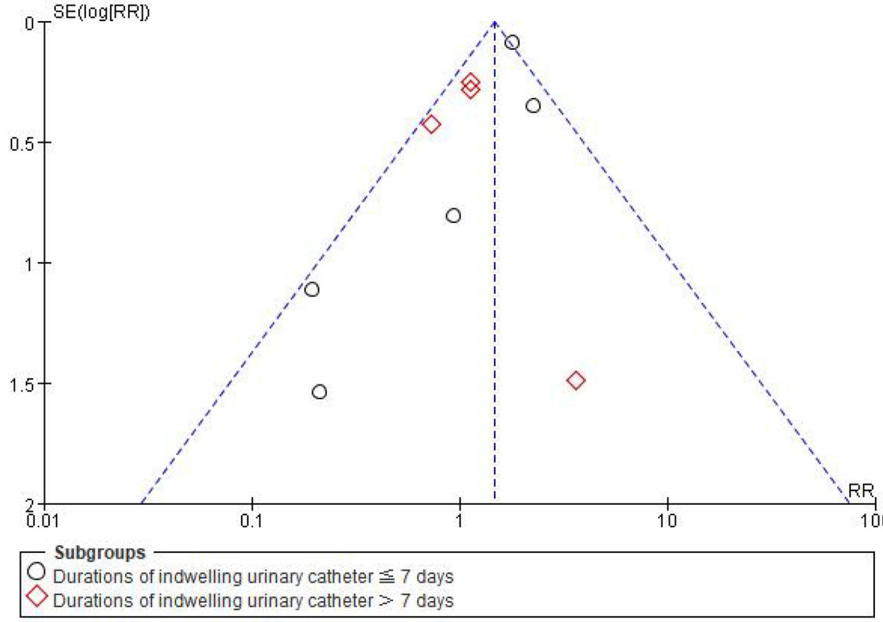

Figure 9 The funnel plot of urinary tract infection.

between female and male pelvic floor muscles may be influencing factors.

Residual urine volume and recatheterisation rates

In the included studies, some authors considered whether it was necessary to recatheterise based on the evaluation of residual urine volume. In Moon's study,[24] residual urine volume was measured immediately after removal using a portable ultrasound device, and recatheterisation was considered based on objective urodynamic testing. However, in a study by Liu *et al*,[37] the residual urine volume was not graded using portable ultrasound equipment, probably for economic reasons, but was based on the patient's subjective perception, the validity of which has not been proven. We also recommend exploring the correlations between outcome indicators in future studies. The residual urine volume is an important indicator of bladder function. A residual urine volume ≤100 mL indicates normal bladder function, whereas that >100 mL indicates abnormal bladder function.[45] However, there were differences in the division of the residual urine volume in the included studies. Zhengyong *et al*[35] did not consider recatheterisation if the residual urine volume was <150 mL. Gong *et al*[34] reset the urinary catheter after 48 hours of removal, with a residual

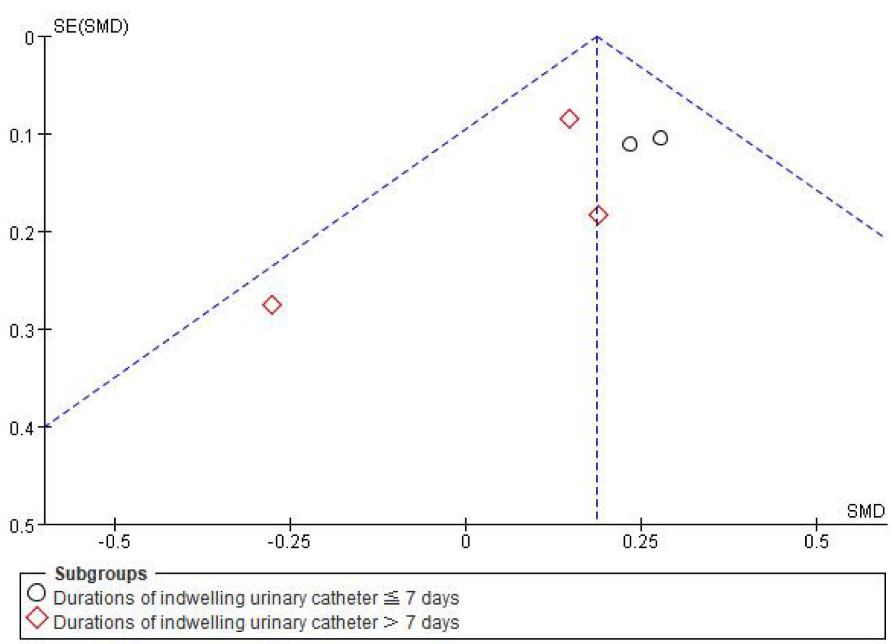

Figure 10 The funnel plot of hours to first void.

urine volume >200 mL. A systematic review conducted by Li *et al*[12] found that clamping of the urinary catheter significantly decreased the incidence of recatheterisation, which is contrary to the findings of this study. However, the credibility of Li's review was uncertain, as only 116 articles were retrieved. Conventionally, patients with prostate cancer are prone to lower urinary tract dysfunction. In all three articles included in the meta-analysis, clamp training was performed in patients with prostate disease or those who underwent surgery. Therefore, it is worth investigating whether to clamp the tube in men with pre-existing prostate dysfunction.

Compared with other studies

In recent years, few studies have directly evaluated the effects of catheter clamping. Most studies do not advocate the use of bladder training during short-term urinary retention to improve bladder function. Most studies did not conduct a subgroup analysis to discuss the impact of clamping training on patients under different factors. The Centers for Disease Control and Prevention guidelines[46] have indicated that clamping should not be used for short-term indwelling urinary catheters. A systematic review conducted by Wang *et al*[10] indicated that there was no significant difference in outcomes between the clamping and free drainage groups. The results of the guidelines and systematic reviews were similar to those of our review. We further found that the clamping group had a significantly increased risk of UTI and lengthened hours to first void in a more specific duration of ≤7 days. For a duration of >7 days, there was no significant difference between clamping and free drainage owing to the limited number of studies. Cochrane's subgroup analysis based on the time to removal of the urinary catheter showed no statistically significant difference between the clamped and unclamped groups. The quality of evidence of a systematic review conducted by Cochrane[14] was low or very low. This review has some moderate quality of evidence, which may be due to the high volume of literature included in the meta-analysis and relatively narrow 95% CI and low heterogeneity. However, more high-quality studies on catheters with a usage duration >7 days are needed to further discuss the role of clamping.

In addition, the latest guidelines[18] state that alternatives to long-term indwelling urinary catheters, such as intermittent catheterisation, external urinary collectors or suprapubic cystostomy, should be used whenever possible to reduce urethral injury and irritation to patients and increase patient comfort. Although this view has been widely adopted and applied, the acceptance of suprapubic cystostomy varies from country to country owing to cultural differences. In China, a large proportion of patients with bladder dysfunction still uses long-term indwelling urinary catheters.[47] Therefore, the question of whether to exercise bladder function in patients with long-term indwelling urinary catheters using tube clamping needs to be addressed. The results of this study showed that clamping the urinary catheters does not achieve the anticipated effect of improving bladder function, which provided some basis for this question. Larger RCTs on clamping long-term indwelling urinary catheter training to further confirm the accuracy of our study are warranted.

CONCLUSION

The results of this meta-analysis showed that clamping urinary catheters increases the incidence of UTI and lengthen the hours to first void in patients with indwelling urinary catheters for ≤7 days compared with the free drainage. The effect of clamping training on the duration of indwelling urinary catheters for >7 days is uncertain. Therefore, bladder training with clamping before catheter removal is not recommended as a routine method. More well-designed RCTs on bladder dysfunction patients with an indwelling urinary catheter duration of >7 days are needed to provide the best evidence for clinical care practice.

Implications

The results of this meta-analysis have implications for clinical practice, policy and further research. First, we do not recommend adopting clamping catheters for bladder training and all usage durations. Second, we hope that the government and private foundations will emphasise how to improve bladder dysfunction in patients with indwelling catheters. Third, future trials should use a more rigorous and robust methodology, especially for allocation concealment, blinding of outcome assessments and selective reporting. For outcome measurements, selecting objective definitions and unified measurement methods may be more optimal.

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