



# The incidence of urinary tract infection of different routes of catheterization following gynecologic surgery: a systematic review and meta-analysis of randomized controlled trials

Meixuan Li<sup>1,2,3,4</sup> · Liang Yao<sup>5</sup> · Caiwen Han<sup>6,7,8</sup> · Huijuan Li<sup>1,2,3,4</sup> · Yangqin Xun<sup>1,2,3,4</sup> · Peijing Yan<sup>6</sup> · Meng Wang<sup>1</sup> · Wenbo He<sup>1</sup> · Cuncun Lu<sup>2,3,4</sup> · Kehu Yang<sup>1,2,3,4,6</sup>

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## Abstract

**Introduction and hypothesis** We performed a systematic review of randomized controlled trials to assess the incidence of urinary tract infection (UTI) and complications of different urinary drainage methods (indwelling urinary catheterization, suprapubic catheterization, and intermittent catheterization.).

**Methods** PubMed, EMBASE, and Cochrane Library were systematically searched from their inception to March 2018. We selected randomized controlled trials (RCTs) comparing at least two of the three possible urinary drainage routes after gynecologic surgery. A meta-analysis was performed using the RevMan software, and a random-effects model was used to pool the effect size. The Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) approach was used to rate the quality of evidence.

**Results** Fifteen RCTs met eligibility criteria ( $N = 1607$ ), the meta-analysis indicated that suprapubic drainage was associated with a reduction in the rate of asymptomatic bacteriuria compared with indwelling urinary catheterization [risk ratios (RR) = 0.39, 95% confidence interval (CI): 0.24–0.65,  $P = 0.0003$ ] but was associated with a higher rate of hematuria (RR = 4.49, 95% CI: 1.16–17.41,  $P = 0.03$ ). Indwelling urinary catheterization increased the rate of recatheterization compared with suprapubic drainage (RR = 2.95, 95% CI: 1.22–7.11,  $P = 0.02$ ) and was associated with higher rate of symptomatic UTI compared with intermittent catheterization (RR = 2.79, 95% CI: 1.09–7.14,  $P = 0.03$ ). No difference was found in other aspects (complication rate and catheter-related pain) among the three drainage routes.

**Conclusions** This meta-analysis suggested that suprapubic drainage was superior to indwelling urethral catheterization in reduction of asymptomatic bacteriuria and rate of recatheterization but was associated with higher rate of hematuria. Intermittent catheterization was associated with a reduction in symptomatic UTI compared with indwelling urinary catheterization. More high-quality randomized trials are needed to determine which route is most appropriate for catheterization in patients after gynecologic surgery.

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Meixuan Li and Liang Yao are co-first author.

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✉ Kehu Yang  
kehuyangebm2006@126.com

- <sup>1</sup> School of Public Health, Lanzhou University, 199 Donggang West Road, Lanzhou, China
- <sup>2</sup> Evidence Based Medicine Center, Lanzhou University, Lanzhou 730000, People's Republic of China
- <sup>3</sup> Evidence Based Social Science Research Center, Lanzhou 730000, People's Republic of China
- <sup>4</sup> Key Laboratory of Evidence Based Medicine and Knowledge Translation of Gansu Province, Lanzhou 730000, People's Republic of China

<sup>5</sup> Chinese Medicine Faculty of Hong Kong Baptist University, Hong Kong 999077, People's Republic of China

<sup>6</sup> Institution of Clinical Research and Evidence Based Medicine, The Gansu Provincial Hospital, Lanzhou 730000, People's Republic of China

<sup>7</sup> Department of General Surgery, Gansu Provincial Hospital, Lanzhou 730000, People's Republic of China

<sup>8</sup> Department of Clinical Medicine, Gansu University of Traditional Chinese Medicine, Lanzhou 730000, People's Republic of China

**Keywords** Gynecologic surgery · Urinary catheter · Suprapubic catheterization · Intermittent catheterization · Bladder drainage

## Abbreviations

RCT	Randomized clinical trial
CI	Confidence interval
RR	Risk ratio

## Introduction

Urinary retention is a common occurrence after gynecologic surgery [1], and estimates vary widely from 2.5 to 43%, depending on the definition used and type of surgery performed [1–3]. If the problem is left untreated, residual urine may cause bladder atony, detrusor instability, voiding difficulties, and increased risk of infection [4]. At present, management of postoperative urinary retention is usually centered on primary prevention with bladder drainage, which can prevent overdistension of the bladder resulting in a compromised detrusor muscle and prolonged voiding dysfunction [1, 2].

The commonly used routes for bladder drainage in gynecologic patients are indwelling urinary catheterization, suprapubic catheterization, and intermittent catheterization. Indwelling and suprapubic catheterization are traditional options; however, intermittent catheterization is being investigated to replace those routes. All methods have advantages and disadvantages, and there are no practical guidelines for their use, as efficacy is still controversial [5, 6]. In recent years, some studies compared the effectiveness of the three drainage routes demonstrating conflicting results. Several randomized controlled trials (RCTs) [7–9] reported that suprapubic have advantages over indwelling catheters, including lower rates of urinary tract infection (UTI), less need for recatheterization, less discomfort, but higher rates of complications. Some studies [10–12] indicated that intermittent catheterization could reduce UTI, hospital stay, and costs and improve patient satisfaction compared with suprapubic catheterization. However, Jannelli et al. [13] concluded that there was no significant difference in the risk of bacteriuria between intermittent and suprapubic catheterization, and patients reported more frustration and difficulty with intermittent catheterization.

These heterogeneous results make it difficult to draw conclusions on the effectiveness, acceptability, and complication rate of every drainage route after gynecologic surgery. We performed a systematic review and meta-analysis of randomized controlled trials to assess the incidence of UTI and complications of the three routes following gynecologic surgery.

## Methods

### Search strategy and selection criteria

#### Search strategy

The systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [14] as well as some other reporting guidelines [15, 16]. The following databases were systematically researched: PubMed, EMBASE, and Cochrane Library from their inception to March 2018, and the last search was updated on August 2018. We did free-text terms and Mesh searches for the terms gynecologic surgery, gynecologic surgical procedures, hysterectomy, vaginal repair, pelvic organ prolapse repair, midurethral sling, colporrhaphy, urinary catheter, suprapubic catheter, transurethral catheter, transurethral tube, intermittent catheter, intermittent self-catheter, in–out catheter and so on (*see* “Appendix 1”). In addition, we checked reference lists of relevant reviews for additional studies to ensure comprehensive data collection. Finally, we transferred all relevant titles and abstracts to Endnote Web for selection.

#### Selection criteria

Two authors (MX-L and YQ-X) independently screened all titles and abstracts of retrieved citations, evaluated potential full texts, and determined eligibility. Disagreements were resolved through discussion and consensus or by consulting a third member (L-Y) of the review team. Studies that met the following criteria were included: randomized clinical trial; suprapubic catheterization compared with indwelling urethral catheterization or intermittent urethral catheterization or indwelling urethral catheterization versus intermittent urethral catheterization; patients undergoing elective or emergency gynecologic surgery for benign or malignant conditions. Trials included at least one quantitative outcome data (UTI, rates of recatheterization, duration of catheterization, hospital stay, complication rate, catheter-related pain). We excluded review articles, editorials, comments, meeting abstracts, and irrelevant topic studies.

#### Definitions of different drainage routes

Indwelling catheterisation was defined by the passage of a catheter into the urinary bladder via the urethra using an inflatable balloon or other means to retain it in position. Intermittent catheterization, also known as in–out catheterisation, was defined as emptying the bladder via the urethra using a catheter that is removed after the procedure, mostly at regular intervals. Suprapubic catheterization was defined as the

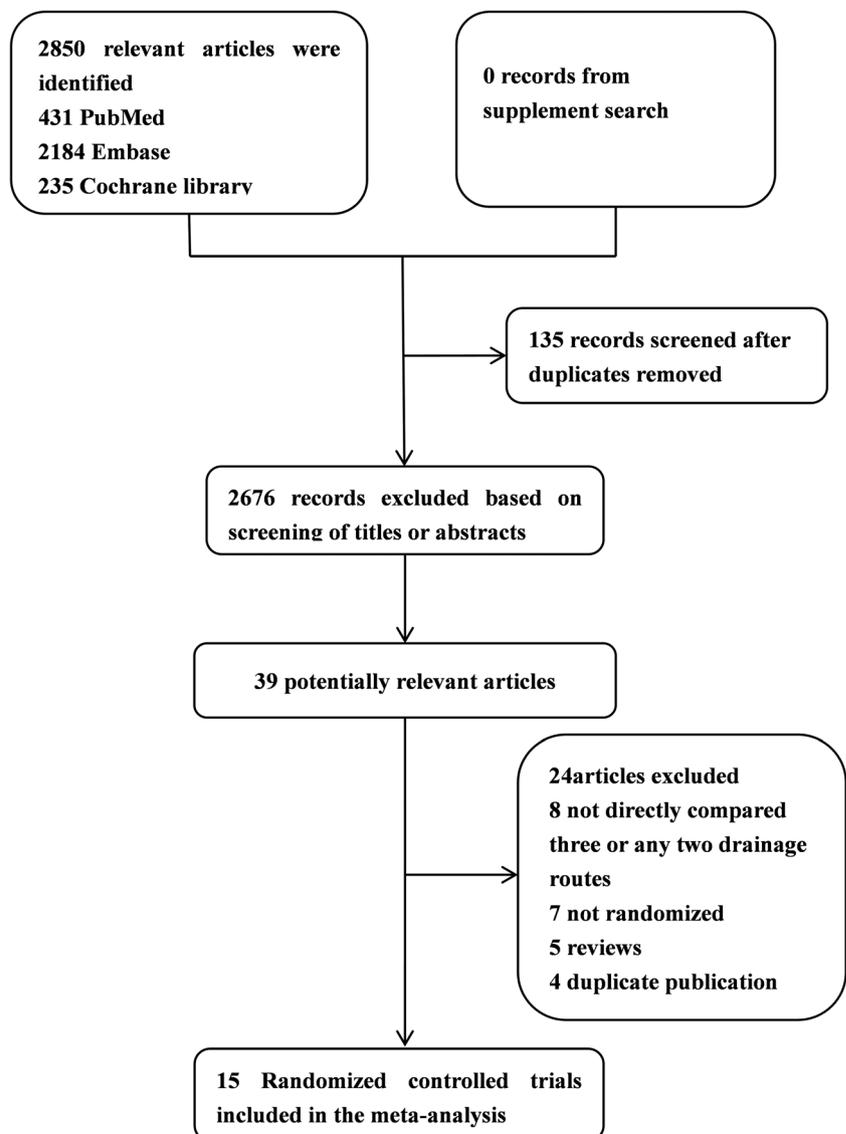
insertion of a catheter into the bladder via the anterior abdominal wall using sutures or other means to retain it in position.

### Data extraction and quality assessment

Two reviewers (CW-H and MX-L) independently extracted relevant data from all the included studies using a standardized, predesigned extraction form in Microsoft Excel 2010. The extracted information included study characteristics (first author, country, number of study participants, procedure, interventions, exclusion criteria, definition of bacteriuria) and outcomes. The primary outcome was UTI, and secondary outcomes were the need for recatheterization, duration of catheterization, hospital stay, catheter-related complications, and pain. UTI data was extracted within 14 days, because many studies reported related data within this timeframe. If information was unclear or missing, we contacted the original authors by e-mail.

Two authors (MX-L and CW-H) independently assessed the risk of bias using the Cochrane Collaboration's tool [17]. Each study was determined as having a low, high, or unclear risk of bias relating to sequence generation, allocation concealment, blinding of outcome assessors, incomplete outcome data, selective outcome reporting, and other sources of bias. Any disagreement was resolved via discussion among the authors. We used Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) system [18] to assess the quality of evidence associated with specific outcomes and constructed a summary of findings table. The GRADE approach is used to assess the quality of a body of evidence based on the extent to which one can be confident that an estimate of effect or association reflects the item being assessed. Assessment of the quality of evidence considers study methodological quality, directness of the evidence, heterogeneity of data, precision of effect estimates, and risk of publication bias [19, 20].

**Fig. 1** Flowchart of the meta-analysis



**Table 1** Characteristics of included studies in the meta-analysis

Author	Country	No. participants	Procedure	Exclusion criteria	Definition of UTI or bacteriuria
Andersen [29] 1985	Denmark	92	Colposuspension/ vaginal repair	Recurrent UTI, steroid use, significant preoperative bacteriuria	$10^5$ cfu/ml on the 5th postoperative day. Specimens obtained by catheter in control group and by midstream in treatment group
Bergman [25] 1987	US	51	Vaginal retropubic urethropexy (Peyrera)	NR	>1000 cfu/ml in 1st 5 postoperative days. Specimens aspirated from drainage tube before surgery and every 2 days thereafter
Harms [26] 1985	Germany	157	Vaginal hysterectomy and repair	Preoperative UTI	Significant bacteriuria defined as $10^5$ cfu/ml on 6th postoperative day
Barents [24] 1978	Netherlands	130	Vaginal hysterectomy and repair	Preoperative UTI, preoperative treatment with antibiotic for other causes other than UTI	$\geq 10^5$ cfu/ml postoperative day 5. Specimens aspirated from drainage tube on 5th and 7th postoperative day and day of catheter removal
Wiser [28] 1974	US	150	Vaginal hysterectomy and repair	Endometriosis, PID, pelvic masses, preoperative bacteriuria, medical disorders, diabetes disorders, neurologic disorders	Significant bacteriuria defined as > $10^4$ ; 4 cfu/ml on 4th postoperative day
Kringel [8] 2010	Vietnam	232	Anterior colporrhaphy	Preoperative UTI or bacteriuria, previous vaginal prolapse surgery	Urine sample on postoperative day 4; asymptomatic bacteriuria defined using CDC definition
Nwabinehi [27] 1993	UK	24	Radical hysterectomy	Older than 56 years, prior voiding dysfunction or radiotherapy, tricyclic antidepressant or anticholinergic use	Significant bacteriuria defined as > $10^5$ cfu/ml. Daily catheter specimens examined bacteriologically until catheter was removed.
Schiotz [9] 1989	Norway	78	Vaginal plastic surgery	Positive preoperative urine cultures	> $10^5$ cfu/ml. Specimens obtained preoperatively, at catheter removal, at follow-up 6–8 weeks postoperatively, and when clinically indicated
Stekkinger [7] 2011	Netherlands	126	Vaginal prolapse repair	Concomitant continence procedure, previous urinary retention or UTI, known urological disease or renal impairment, language barrier	Presence of > $10^5$ cfu/ml in culture
Naik [12] 2005	UK	40	Radical hysterectomy	NR	NR
Jannelli [13] 2007	US	210	Urogynecologic surgery	Preoperative bacteriuria or urinary retention, history voiding dysfunction or urethral trauma	> $10^5$ cfu/ml on postoperative day 2 or 7
Dixon [10] 2010	UK	75	Urodynamic stress incontinence or uterovaginal prolapse	Catheter not routinely used, requiring continuous postoperative bladder drainage	NR
Bray [11] 2017	UK	60	Vaginal prolapse surgery	Inability to give informed consent, concomitant continence procedure (midurethral slings, colposuspension, Kelly plication sutures), preoperative voiding dysfunction or UTI	UTI defined as positive urine culture of > $10^5$ cfu/ml
Dobbs [30] 1997	UK	95	Hysterectomy	NR	Significant bacteriuria defined as > $10^5$ cfu/ml. Specimens collected on second postoperative day
Hakvoort [31] 2011	Netherlands	87	Vaginal prolapse surgery	Any neurologic or anxiety disorder, need for concomitant anti-incontinence surgery	> $10^5$ cfu in voided culture obtained upon normalization of PVR and cessation of catheterisation

NR not reported, UTI urinary tract infection

## Statistical analysis

This meta-analysis was performed using the RevMan version 5.3 (Cochrane Collaboration) [21]. Dichotomous variables were evaluated using risk ratio (RR) with 95% confidence intervals (95% CI). Continuous variables were analyzed using mean differences (MD) and 95% CI. When studies reported on medians, ranges, or *P* values for continuous variables, statistical algorithms were used to derive the appropriate means and standard. A random-effects model was used for pooling studies, because it takes into account the almost inevitable natural variation inherent between studies and is especially useful in conducting surgical research [22]. Meta-analyses of binary variables were performed using the Mantel–Haenszel method and continuous variables using the inverse variance method. Heterogeneity was assessed using Cochran Q test and  $I^2$  statistic. We conducted subgroup analyses according to UTI (asymptomatic bacteriuria and symptomatic UTI). Sensitivity analysis was performed for the primary outcome by excluding some low-quality studies; publication bias was performed using Egger's test if the number of studies was ten or more [23].

## Results

### Literature search

The literature search yielded 2850 reports; 135 were excluded because of duplication and 2676 were excluded on the basis of title or abstract that was irrelevant to the topic; 24 were excluded from the remaining 39 after reading the full text. Therefore, 15 RCTs were included in this systematic review. Nine trials [7–9, 24–29] ( $n = 1040$ ) compared indwelling urethral catheterization with suprapubic catheterization, four [10–13] ( $n = 385$ ) compared intermittent catheterization with suprapubic catheterization, and two [30, 31] ( $n = 182$ ) compared indwelling urethral catheterization with intermittent catheterization. The PRISMA flow chart of literature studies for meta-analysis is illustrated in Fig. 1.

### Study characteristics

The basic characteristics of the included studies were extracted and are listed in Table 1. The 15 studies were all published in English between 1974 and 2017, and study samples ranged from 24 to 232 participants. Exclusion criteria were reported by 12 of 15 trials, many of which focused on preoperative UTI or bacteriuria or some other urological diseases.

### Quality assessment

The risk of bias is shown in Table 2. All studies were randomized, ten trials [7, 8, 10, 11, 13, 25, 26, 28, 29, 31] described an

**Table 2** Risk of study bias

Author	Year	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Andersen [29]	1985	Low risk	Unclear risk	High risk	Unclear risk	Unclear risk	Unclear risk	Low risk
Bergman [25]	1987	Low risk	Unclear risk	High risk	Unclear risk	Low risk	Unclear risk	Low risk
Harms [26]	1985	Low risk	Unclear risk	High risk	Unclear risk	Low risk	Unclear risk	Low risk
Barents [24]	1978	High risk	High risk	High risk	Unclear risk	Unclear risk	Unclear risk	Low risk
Wiser [28]	1974	Low risk	Low risk	High risk	Unclear risk	Unclear risk	Unclear risk	Low risk
Kringel [8]	2010	Low risk	Unclear risk	High risk	Low risk	Unclear risk	Unclear risk	Unclear risk
Nwabineli [27]	1993	Unclear risk	Unclear risk	High risk	Unclear risk	Unclear risk	Unclear risk	Unclear risk
Schlotz [9]	1989	Unclear risk	Unclear risk	High risk	Unclear risk	Unclear risk	Unclear risk	Unclear risk
Stekkinger [7]	2011	Low risk	Low risk	High risk	Unclear risk	Low risk	Low risk	Low risk
Naik [12]	2005	Unclear risk	Unclear risk	High risk	Unclear risk	Low risk	Unclear risk	Low risk
Jannelli [13]	2007	Low risk	Low risk	High risk	Unclear risk	High risk	Low risk	Unclear risk
Dixon [10]	2010	Low risk	Low risk	High risk	Unclear risk	Low risk	Low risk	Unclear risk
Bray [11]	2017	Low risk	Unclear risk	High risk	High risk	Low risk	Low risk	Low risk
Dobbs [30]	1997	Unclear risk	Low risk	High risk	Unclear risk	Unclear risk	Low risk	Unclear risk
Hakvoort [31]	2011	Low risk	High risk	High risk	High risk	Low risk	Low risk	Low risk

adequate random-sequence generation process; five trials [7, 10, 13, 28, 30] described the methods used for allocation concealment; 1 trial [8] described the blind of outcome assessment. All studies reported complete outcome data or selective outcome reporting. Overall, study quality was low. The quality of evidence is shown in Table 3.

## Meta-analysis

### Urinary tract infection

Fifteen trials [7–13, 24–31] reported the incidence of UTI compared with the three drainage routes. We conducted subgroup analyses according to symptoms of UTI (asymptomatic bacteriuria and symptomatic UTI). The meta-analysis indicated that suprapubic drainage was associated with a reduction in asymptomatic bacteriuria compared with indwelling catheterization (RR = 0.39, 95% CI: 0.24–0.65,  $P = 0.0003$ ); indwelling catheterization may increase symptomatic UTI compared with intermittent catheterization (RR = 2.79, 95% CI: 1.09–7.14,  $P = 0.03$ ). There were no differences in the other comparisons (Fig. 2).

### Rate of recatheterization

Four studies [7, 26, 28, 29] specifically reported rates of recatheterization between suprapubic and indwelling urethral catheterization. No studies reported the outcome between suprapubic and intermittent catheterization or between indwelling urethral and intermittent catheterization. Indwelling catheterization was associated with higher rate of recatheterization compared with suprapubic catheterization (RR = 2.95, 95% CI 1.22–7.11,  $P = 0.02$ ) (Fig. 3).

### Duration of catheterization

Two trials [9, 27] addressed duration of catheterization as a specific outcome and compared suprapubic with indwelling urethral catheterization. Three studies [10, 12, 13] reported the outcome of suprapubic vs intermittent catheterization. No significant difference was found between suprapubic and

indwelling urethral catheterization (MD = -0.69, 95% CI -4.47 to 3.10 days,  $P = 0.72$ ), suprapubic and intermittent catheterization (MD = 0.37, 95% CI -1.34 to 2.09 days,  $P = 0.67$ ). There was no evidence of heterogeneity in the two comparisons ( $I^2 = 33%$ ,  $I^2 = 0%$ , respectively, Fig. 4).

### Hospital stay

Three trials [7, 8, 25] provided data on hospital stay and compared suprapubic with indwelling urethral catheterization. Two studies [10, 11] reported comparison between suprapubic and intermittent catheterization. There was no significant difference between suprapubic and indwelling urethral catheterization (MD = 0.21, 95% CI -0.56 to 0.98,  $P = 0.59$ ). There was evidence of heterogeneity ( $I^2 = 78%$ ,  $P = 0.01$ , Fig. 5). The high heterogeneity may be because most studies did not define the length of the hospital stay. There was also no difference between suprapubic and intermittent catheterization (MD = 1.33, 95% CI -0.09 to 2.76,  $P = 0.07$ ). There was no evidence of heterogeneity ( $I^2 = 0%$ ,  $P = 0.52$ , Fig. 5).

### Complication rate

Eight trials [7–9, 13, 25, 26, 28, 30] reported specific data for the complication rate associated with each intervention. Common complications reported included urinary retention, urine leakage, catheter blockage, hematuria, spontaneous loss of catheter, and voiding difficulty. Use of suprapubic catheterization was associated with a higher rate of hematuria compared with indwelling urethral catheterization (RR = 4.49, 95% CI 1.16–17.41,  $P = 0.03$ , Table 4). No difference was found in the rate of other complications between groups.

### Catheter-related pain

Data regarding catheter-related pain were available for two trials [10, 13] that compared suprapubic with intermittent catheterization. They both concluded there was no difference between groups, but they assessed pain using different scales.

**Table 3** Postoperative complication rates

Postoperative complications	Studies	No. patients	RR	95% CI	<i>P</i> value	<i>I</i> <sup>2</sup> (%)
Suprapubic versus indwelling						
Catheter blockage	3	360	3.34	0.26–43.53	0.36	69
Urinary retention	1	520	4.00	0.78–20.42	0.10	NA
Urine leakage	1	126	0.97	0.20–4.62	0.97	NA
Hematuria	2	276	4.49	1.16–17.41	0.03	0
Catheter lost spontaneously	1	126	10.66	0.60–188.84	0.11	NA
Voiding difficulty	1	150	0.25	0.03–2.18	0.21	NA
Suprapubic versus intermittent						
Catheter obstruction	1	200	2.63	0.11–63.79	0.55	NA

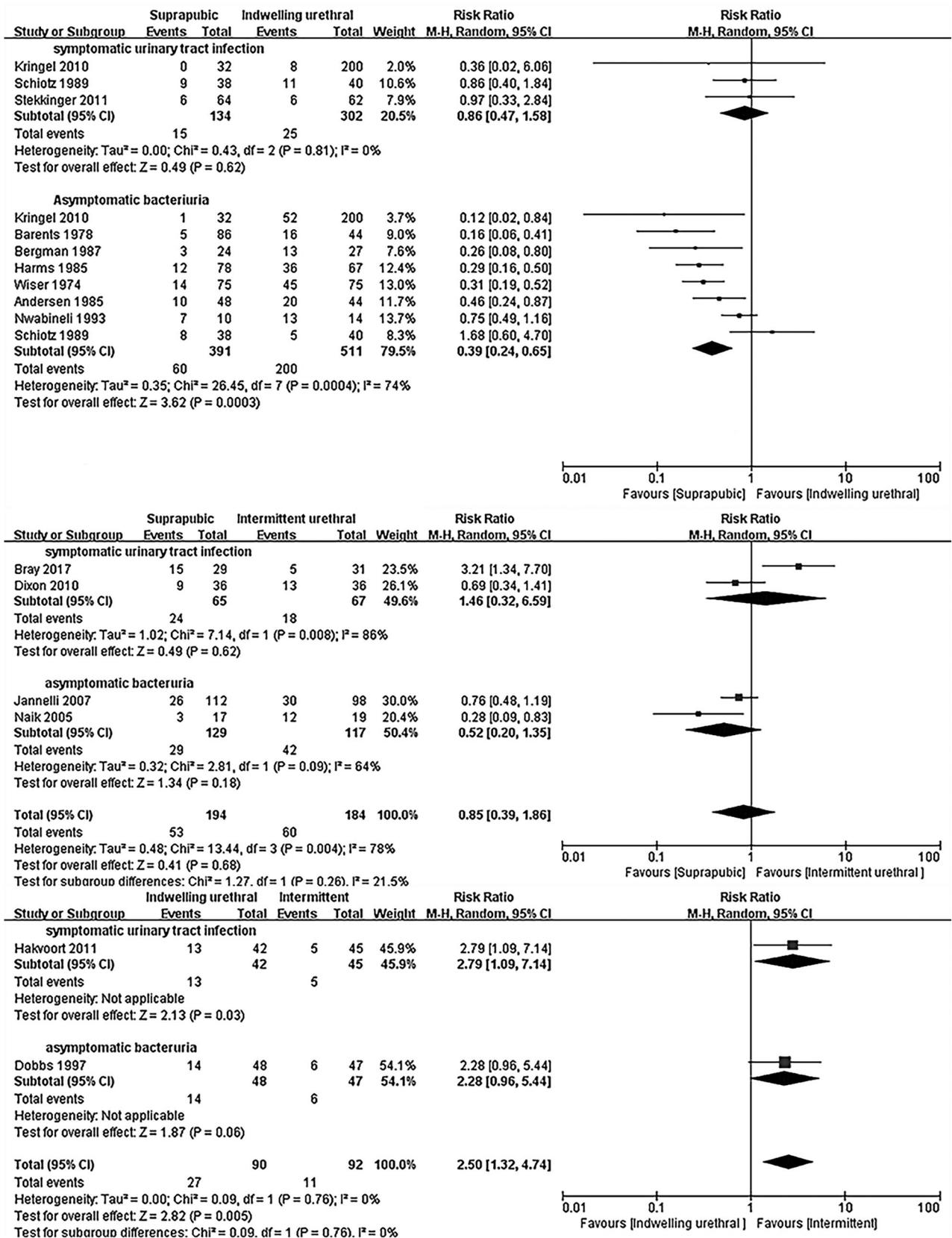


Fig. 2 Forest plot of urinary tract infection

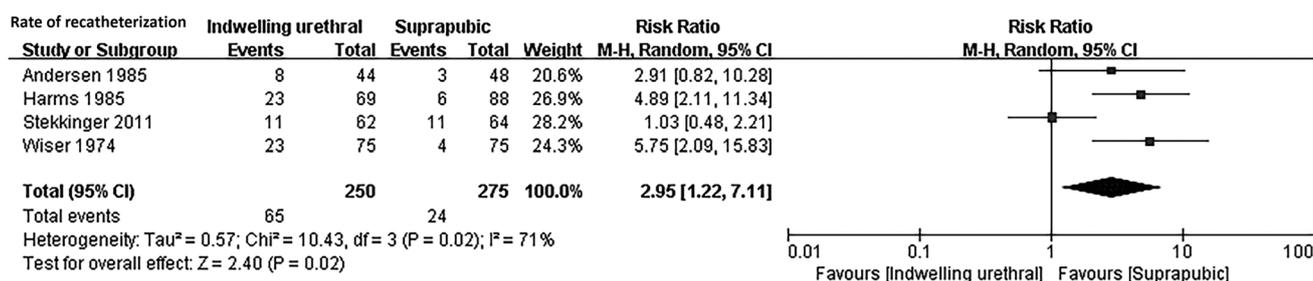


Fig. 3 Forest plot of rate of recatheterization

Due to evidence of significant clinical and statistical heterogeneity, we did not pool the results.

### Sensitivity analysis

Sensitivity analysis was conducted for the primary outcome UTI. We removed two trials [10, 12] that did not report their definition for UTI or bacteriuria, results were stable.

### Publication bias

As described, we perform publication bias analysis if the number of studies is ten or more. As this did not apply to the analysis reported here, publication bias analysis was not conducted.

### Discussion

Our systematic review and meta-analysis demonstrated that use of suprapubic catheterization was associated with a reduction in asymptomatic bacteriuria and rate of recatheterization compared with indwelling urinary catheterization for gynecological

surgery patients; however, suprapubic catheterization was associated with higher rate of hematuria compared with indwelling. Intermittent catheterization reduced the rate of symptomatic UTI compared with indwelling catheterization. There was no difference in other aspects among the three drainage routes. As shown in Table 3, the quality of evidence for the reported outcomes was low or very low. We downgraded quality of evidence by one or two levels for the following reasons: serious risk of bias; inconsistency of results; imprecision of results.

The European Association of Urology 2015 guidelines on urological infection recommend that intermittent urethral catheterization was associated with a reduction in the incidence of bacteriuria compared with indwelling urethral catheterization [32]. However, they could not make any recommendations for symptomatic UTI. UTI alone results in >3 million medical visits by women annually, require antibiotics that can be expensive, and can have serious consequences, such as pyelonephritis, which is increasingly important in our aging population. More serious is that the presence of a UTI increases the risk of mortality almost three times, even after controlling for comorbidities [33–35]. Up to 20–36% of patients with UTI have bacteremia [36, 37]. We conducted subgroup analysis

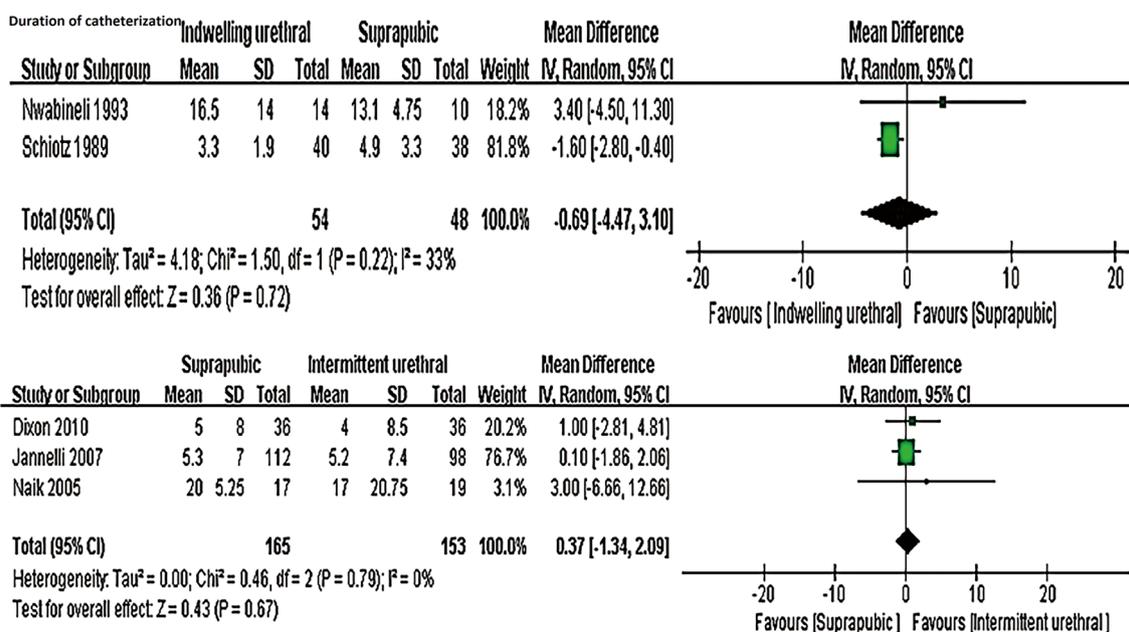


Fig. 4 Forest plot of duration of catheterization

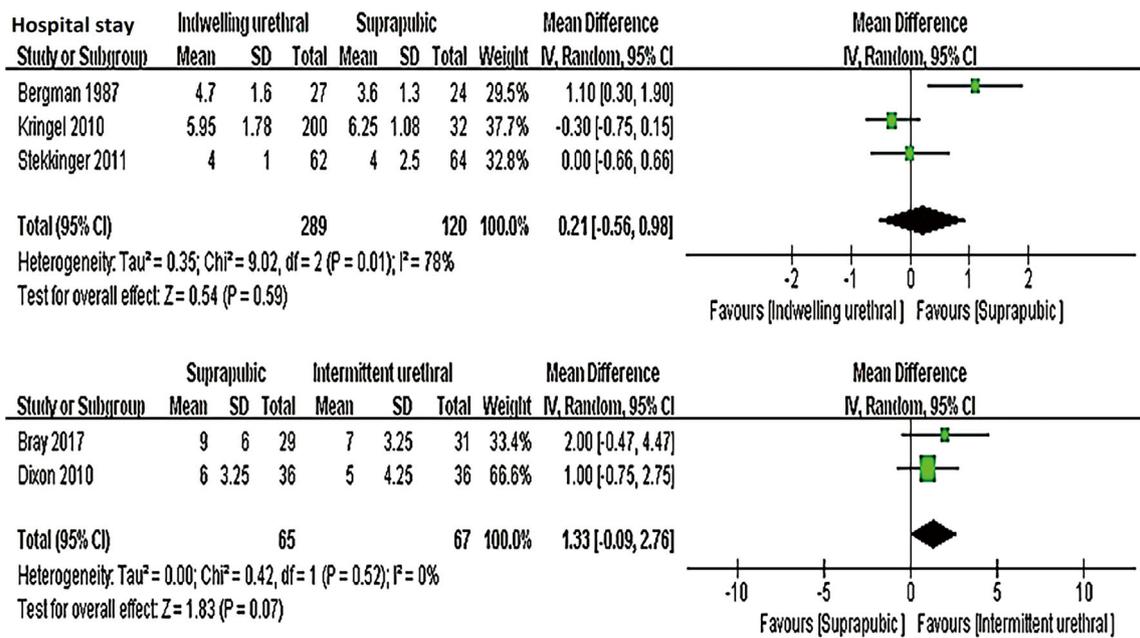


Fig. 5 Forest plot of hospital stay

Table 4 Summary of findings

Suprapubic catheterization compared to indwelling urethral catheterization for patients after gynecologic surgery						
Patient or population: patients after gynecologic surgery						
Setting: Hospital						
Intervention: suprapubic catheterization						
Comparison: indwelling urethral catheterization						
Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with indwelling urethral catheterization	Risk with suprapubic catheterization				
Urinary tract infection (UTI)	277 per 1,000	<b>127 per 1,000</b> (83 to 194)	<b>RR 0.46</b> (0.30 to 0.70)	1338 (9 RCTs)	⊕⊕⊕○ MODERATE	
Rate of recatheterization	260 per 1,000	<b>767 per 1,000</b> (317 to 1,000)	<b>RR 2.95</b> (1.22 to 7.11)	525 (4 RCTs)	⊕○○○ VERY LOW	
Duration of catheterization		The mean duration of catheterization in the intervention group was 0.69 lower (4.47 lower to 3.1 higher)	-	(2 RCTs)	⊕⊕○○ LOW	
Hospital stay		The mean hospital stay in the intervention group was 0.21 higher (0.56 lower to 0.98 higher)	-	(3 RCTs)	⊕⊕○○ LOW	
Catheter blockage	19 per 1,000	<b>62 per 1,000</b> (5 to 810)	<b>RR 3.34</b> (0.26 to 43.53)	360 (3 RCTs)	⊕○○○ VERY LOW	
Urinary retention	25 per 1,000	<b>100 per 1,000</b> (20 to 511)	<b>RR 4.00</b> (0.78 to 20.42)	520 (1 RCT)	⊕○○○ VERY LOW	

Table 4 (continued)

Suprapubic catheterization compared to intermittent catheterization for patients after gynecologic surgery						
Patient or population: patients after gynecologic surgery						
Setting: hospital						
Intervention: Suprapubic catheterization						
Comparison: intermittent catheterization						
Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with intermittent catheterization	Risk with Suprapubic catheterization				
Urinary tract infection	288 per 1,000	<b>302 per 1,000</b> (127 to 729)	<b>RR 0.85</b> (0.39 to 1.86)	378 (4 RCTs)	⊕⊕○○ LOW	
Rate of recatheterization			not estimable		Not reported	
Duration of catheterization		The mean duration of catheterization in the intervention group was 0.37 higher (1.34 lower to 2.09 higher)	-	(3 RCTs)	⊕⊕○○ LOW	
Hospital stay		The mean hospital stay in the intervention group was 1.33 higher (0.09 lower to 2.76 higher)	-	(2 RCTs)	⊕⊕○○ LOW	
catheter obstruction	9 per 1,000	<b>23 per 1,000</b> (1 to 570)	<b>RR 2.63</b> (0.11 to 63.79)	210 (1 RCT)	⊕○○○ VERY LOW	
Urinary retention			not estimable		Not reported	

according to symptoms of UTI (asymptomatic bacteriuria and symptomatic UTI). Our meta-analysis found that suprapubic catheterization was associated with a reduction in asymptomatic bacteriuria compared with indwelling urinary catheterization. Intermittent catheterization may reduce the rate of symptomatic UTI compared with indwelling catheterization. Although there was a significant difference in the rates of symptomatic UTI when comparing intermittent and indwelling catheterization, forest plot showed that the 95% CI was very wide, which may influence the reliability of the results.

The practice of evidence-based medicine means integrating individual clinical expertise with the best available external clinical evidence from systematic research [38]. In our review, we pooled data from 15 RCTs to reach the most reliable conclusion. Our results were inconsistent with those of a previous systematic review [6], published in 2012, which included 12 RCTs ( $N = 1300$ ) and concluded that no route for bladder drainage in gynecologic patients is clearly superior. The reason may be that the earlier review defined UTI as both symptomatic and asymptomatic bacteriuria and it did not perform subgroup analyses. In fact, symptomatic and asymptomatic bacteriuria have different clinical outcomes. Asymptomatic

bacteriuria can be considered an insidious type of UTI. Management of UTI varies greatly. Some clinicians will treat patients with asymptomatic bacteriuria, some will use prophylactic antibiotics, and others will only treat patients with symptomatic UTI. The European and Asian guidelines on Management and Prevention of Catheter-Associated Urinary Tract Infections [39] recommend that asymptomatic bacteriuria should not be treated with antibiotics, as the infection will not be eradicated, or if it is, it will return rapidly. They recommend that symptomatic infections in catheterized patients be treated with broad-spectrum systemic antibiotics, as well as removal and replacement of the catheter. In addition, the review published in 2012 only compared indwelling urinary catheterization with suprapubic catheterization, with no comparison between them and intermittent catheterization, which may influence reliability of results.

With regard to the rates of recatheterization, only four studies [7, 26, 28, 29] ( $N = 525$ ) reported outcomes in the comparison with suprapubic and intermittent catheterization. The meta-analysis indicated that suprapubic vs indwelling catheterization could reduce the rates of recatheterization. That conclusion was different from the previous systematic review [6].

Table 4 (continued)

**Indwelling catheterization compared to intermittent catheterization for patients after gynecologic surgery****Patient or population:** patients after gynecologic surgery**Setting:** hospital**Intervention:** Suprapubic catheterization**Comparison:** intermittent catheterization

Outcomes	Anticipated absolute effects <sup>a</sup> (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with intermittent catheterization	Risk with Suprapubic catheterization				
Urinary tract infection	188 per 1,000	<b>224 per 1,000</b> (141 to 353)	<b>RR 2.50</b> (1.32 to 4.74)	182 (2 RCTs)	 LOW	
Rate of recatheterization			not estimable		Not reported	
Duration of catheterization			not estimable		Not reported	
Hospital stay			not estimable		Not reported	
catheter obstruction			not estimable		Not reported	
Urinary retention			not estimable		Not reported	

GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

CI Confidence interval, RR Risk ratio, MD Mean difference

\*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI)

The difference between the earlier and our meta-analysis may be that more trials were included in our study. However, in one study, the sample size of the experimental and control groups was significantly different, which may cause unavoidable clinical and statistical heterogeneity. Larger samples and higher-quality studies are needed to confirm our conclusions. At present, we believe that suprapubic catheterization is superior for reducing recatheterization rates.

Catheterization can effectively solve the patient's urinary dysfunction, but it is an invasive procedure that may cause many complications. Our meta-analysis indicated that suprapubic catheterization was associated with higher rate of hematuria compared with indwelling urethral catheterization. It should be applied cautiously in clinical practice. However, our conclusions are based only on limited data; many studies did not report complications after gynecologic surgery, so it is unclear whether they occurred or if they were simply not reported. Future trials should report standardized core outcomes, and we suggest the following variables be included: urinary retention, catheter obstruction, urine leakage, and so on.

## Strengths and limitations

Strengths of this review are that all studies reviewed were RCTs, detailed data collection and extraction was performed on all related studies, quality of evidence was assessed using GRADE, and we provide detailed reporting of results of all extracted outcomes. Limitations are that the quality of evidence was low, which could be challenged regarding results interpretation. Blinding assessment of outcomes rarely occurred; in the future, using blinding is recommended to add rigor to study findings; we should make some changes and pay more attention to blinding of the assessor.

## Conclusions

This meta-analysis showed that suprapubic catheterization was associated with a reduction in the asymptomatic bacteriuria and the rate of recatheterization but increased the occurrence of hematuria compared with indwelling urinary catheterization.

Intermittent catheterization may reduce the rate of symptomatic UTI compared with indwelling catheterization. Due to the low quality and small quantity of available comparative studies, more high-quality randomized trials are needed to provide stronger evidence of the effectiveness of the drainage routes.

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### Compliance with ethical standards

**Conflict of Interest** The authors declare that they have no conflict of interest.

### Appendix 1 search strategy

#1 Gynecologic Surgical Procedures[Mesh]  
 #2 Endometrial Ablation Techniques [Mesh]  
 #3 Hysterectomy[Mesh]  
 #4 Ovariectomy[Mesh]  
 #5 Salpingostomy[Mesh]  
 #6 Uterine Artery Embolization [Mesh]  
 #7 gynecologic surgery[Title/Abstract]  
 #8 pelvic organ prolapse repair[Title/Abstract]  
 #9 vaginal prolapse Repair[Title/Abstract])  
 #10 hysterectomy\*[Title/Abstract]  
 #11 vaginal repair[Title/Abstract]  
 #12 urethral sling[Title/Abstract]  
 #13 colposuspension[Title/Abstract]  
 #14 colporrhaphy[Title/Abstract]  
 #15 vaginal plastic surgery[Title/Abstract]  
 #16 urogynecologic surgery[Title/Abstract]  
 #17 endometrial ablation technique\*[Title/Abstract]  
 #18 ovariectom\*[Title/Abstract]  
 #19 salpingostom\*[Title/Abstract]  
 #20 uterine artery embolization[Title/Abstract]  
 #21 endometrioma\*[Title/Abstract]  
 #22: #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR  
 #9 OR #10 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17  
 OR #18 OR #19 OR #20 OR #21  
 #23 Urinary Catheters[Mesh])  
 #24 Intermittent Urethral Catheterization[Mesh]  
 #25 suprapubic catheter\*[Title/Abstract]  
 #26 Suprapubic Tube[Title/Abstract]  
 #27 transurethral catheter\*[Title/Abstract]  
 #28transurethral tube[Title/Abstract]  
 #29urinary catheter\*[Title/Abstract]  
 #30 urinary tube[Title/Abstract]  
 #31 urethral catheter\*[Title/Abstract]  
 #32 urethral tube[Title/Abstract]  
 #33 techniques catheterization[Title/Abstract]  
 #34 Intermittent Urethral Catheterization[Title/Abstract]

#35 intermittent self catheterization[Title/Abstract]  
 #36 clean intermittent catheterization[Title/Abstract]  
 #37 clean intermittent self-catheterization[Title/Abstract]  
 #38 in–out catheterization[Title/Abstract]  
 #39 intermittent urethral catheterizations[Title/Abstract]  
 #40 urethral self catheterization[Title/Abstract]  
 #41 clean intermittent catheterization[Title/Abstract]  
 #42 bladder drainage[Title/Abstract]  
 #43 #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29  
 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35 OR #36  
 OR #37 OR #38 OR #39 OR #40 OR #41 OR #42  
 #44 #22 AND #43

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