

doi: 10.4081/uij.2026.367

## SUPPLEMENTARY MATERIAL

**Impact of micro-hole zone catheters vs. conventional eyelet catheters on bladder emptying, flow stops, and microtrauma in adults with neurogenic or non-neurogenic lower urinary tract dysfunction requiring clean intermittent catheterization: a systematic review and meta-analysis**

Branson Thamran,<sup>1</sup> Bungaran Sihombing,<sup>1</sup> Steven Steven<sup>2</sup>

<sup>1</sup>Department of Urology, Haji Adam Malik Hospital, Medan; <sup>2</sup>Department of Urology, Universitas Indonesia, Dr. Cipto Mangunkusumo Hospital, Jakarta, Indonesia

**Correspondence:** Branson Thamran, Department of Urology, Haji Adam Malik Hospital, Medan, Indonesia. E-mail: [dr.bransontham@gmail.com](mailto:dr.bransontham@gmail.com)

**Key words:** Micro-hole zone catheter, intermittent catheterization, urinary tract dysfunction, eyelet catheter, conventional urinary catheter.

Note: The publisher is not responsible for the content or functionality of any supporting information supplied by the authors. Any queries should be directed to the corresponding author for the article

## Supplementary Material. Search strategy.

### Searches

#### Pubmed

"Urinary bladder, Neurogenic"[Mesh] OR "Urinary retention"[Mesh] OR "Lower urinary tract dysfunction"[Title/Abstract] OR "urinary retention"[Title/Abstract] OR "neurogenic bladder"[Title/Abstract] AND ("Intermittent urethral catheterization"[Title/Abstract] OR "Clean Intermittent catheterization"[Title/Abstract] OR "Intermittent catheterization"[Title/Abstract] OR CIC[Title/Abstract]) AND "Micro-hole zone catheter" [Title/Abstract] OR "Micro-hole zone catheter"[Title/Abstract] OR "MHZC"[Title/Abstract] AND "flow stop"[Title/Abstract] OR "interrupted urine flow"[Title/Abstract] OR "mucosal suction"[Title/Abstract] OR "Residual urine"[Title/Abstract] OR "postvoid residual"[Title/Abstract] OR "bladder emptying"[Title/Abstract] OR "microtrauma" [Title/Abstract]OR "catheter-related trauma"[Title/Abstract]

#### Cochrane

#1 "Neurogenic lower urinary tract dysfunction" OR "Lower urinary tract symptoms" OR LUTS OR "urinary retention"OR "neurogenic bladder"OR "bladder dysfunction"

#2 "Intermittent urethral catheterization" OR "Clean Intermittent catheterization" OR "Intermittent catheterization" OR CIC

#3 "Micro-hole zone catheter" OR "Micro-hole Catheter" OR "Micro-perforated catheter" OR "Multiple micro-holes catheter" OR "MHZC"

#4 "urinary flow" OR "urine flow-stop" OR "flow stop" OR "interrupted urine flow" OR "mucosal suction") OR "Residual urine" OR "postvoid residual" OR "bladder emptying" OR "incomplete bladder emptying") OR "Hematuria" OR "microtrauma" OR "urothelial injury" OR "bladder injury" OR "catheter-related trauma")

#5 #1 AND #2 AND #3 AND #4

#### Google Scholar

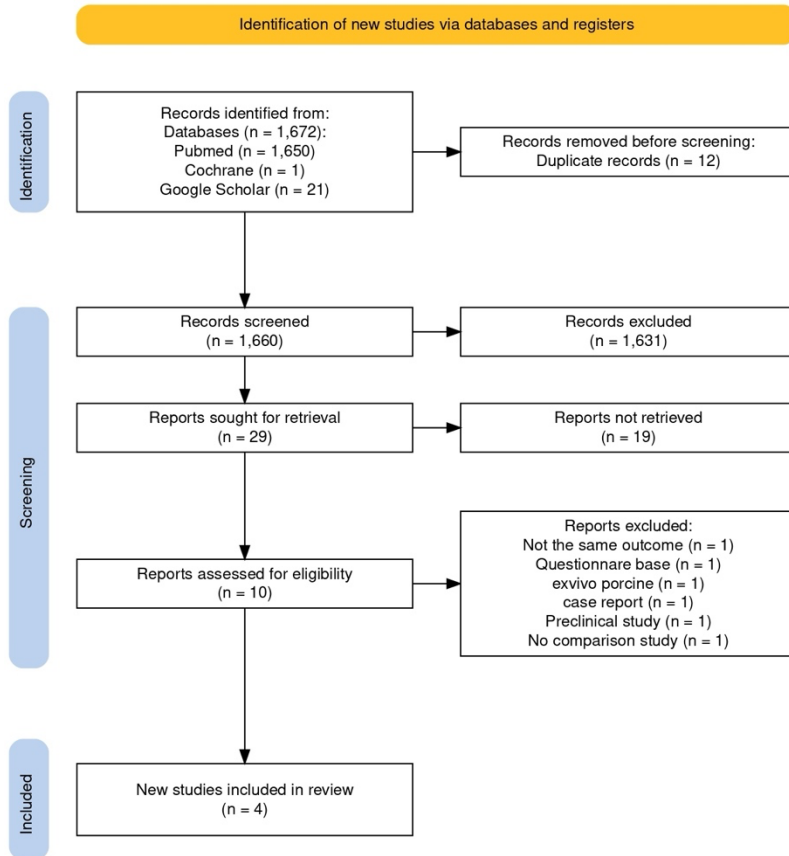
"Lower urinary tract dysfunction" OR "urinary retention" OR "neurogenic bladder" AND ("Intermittent urethral catheterization" OR "Clean Intermittent catheterization" OR "Intermittent catheterization" OR CIC AND "Micro-hole zone catheter" OR "Micro-hole zone catheter" OR "MHZC" AND "flow stop" OR "interrupted urine flow" OR "mucosal suction" OR "Residual urine"OR "postvoid residual"OR "bladder emptying"OR "microtrauma"OR "catheter-related trauma"

Study	Risk of bias domains					Overall
	D1	D2	D3	D4	D5	
Landauro et al., 2023 (JOCM)	+	-	+	+	+	+
Landauro et al., 2023 (JWOCN)	+	-	+	+	-	-
Thiruchelvam et al., 2024( BJON)	+	-	+	+	+	+
Thiruchelvam et al., 2024( Neuroulogy)	+	-	+	+	+	+

Domains:  
D1: Bias arising from the randomization process.  
D2: Bias due to deviations from intended intervention.  
D3: Bias due to missing outcome data.  
D4: Bias in measurement of the outcome.  
D5: Bias in selection of the reported result.

Judgement  
- Some concerns  
+ Low

**Supplementary Figure 1. ROBS-2 analysis among studies.**



**Supplementary Figure 2. PRISMA flow chart.<sup>14</sup>**

**Supplementary Table 1. General characteristics of the study.**

Study (Year)	Country/setting	Study design	Population	Sample size (n)	Intervention	Comparator	Key outcomes assessed	Safety endpoint
Thiruchelvam <i>et al.</i> , 2024 (British J Nursing)	Multicenter, Europe	Randomized controlled cross-over trial	Adult women using CIC (neurogenic and non-neurogenic LUTD)	79 CEC and 79 MHZC	MHZC	CEC	Flow-stops, residual urine at first flow-stop (RV1), user perception	No serious adverse effects were reported in either group. Three participants were in the MHZC group, and four participants were in the CEC group.
Thiruchelvam <i>et al.</i> , 2024 (Neurology Urodynamics)	Multicenter, Europe	Randomized controlled cross-over trial	Adult men using CIC	73 CEC and 73 MHZC	MHZC	CEC	Flow-stops, RV1, intra-catheter pressure, safety	No serious adverse effects were reported in either group. A total of three adverse events occurred across both groups.
Landauro <i>et al.</i> , 2023 (J Clin Med)	Single center, Denmark	Randomized controlled cross-over trial	Adult male CIC users	42 ICEC and 42 MHZC	MHZC	CEC	Flow-stops, RV1, intra-catheter pressure	No adverse effect was reported for both groups.
Landauro <i>et al.</i> , 2023 (J Wound Ostomy Continence Nurse)	Single center, Denmark	Randomized controlled cross-over trials (pooled analysis of 3 studies)	Healthy volunteers and CIC users (male and female)	60 MHZC and 30 CEC	MHZC	CEC	Flow-stops, RV1, post-void residual,	No serious adverse effects were reported in either group. A total of seven adverse events occurred, two in the MHZC group and five in the CEC participants.

CIC, clean intermittent catheterization; LUTD, lower urinary tract dysfunction; MHZC, micro-hole zone catheters; CEC, conventional eyelet catheters.

**Supplementary Table 2. GRADE criteria table showing each criterion-related outcome.<sup>17</sup>**

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	MHZC	Eyelet catheter	Relative (95% CI)	Absolute (95% CI)		
Flow Stop (assessed with: Frequency)												
4	randomised trials	not serious	not serious	not serious	serious <sup>a</sup>	publication bias strongly suspected very strong association <sup>b</sup>	256/256 (100.0%)	256/256 (100.0%)	RR 0.16 (0.09 to 0.28)	840 fewer per 1,000 (from 910 fewer to 720 fewer)	⊕⊕⊕⊕ High <sup>a,b</sup>	CRITICAL
Residual Urine (assessed with: Volume)												
4	randomised trials	not serious	not serious	not serious	serious <sup>a</sup>	publication bias strongly suspected strong association <sup>b</sup>	256/256 (100.0%)	256/256 (100.0%)	RR -21.41 (-40.03 to -2.80)	1,000 fewer per 1,000 (from 1,000 fewer to 1,000 fewer)	⊕⊕⊕○ Moderate <sup>a,b</sup>	CRITICAL
Microtrauma (assessed with: Microscopic)												
4	randomised trials	not serious	not serious	serious <sup>c</sup>	serious <sup>a</sup>	publication bias strongly suspected very strong association <sup>b</sup>	256/256 (100.0%)	256/256 (100.0%)	RR 0.15 (0.09 to 0.26)	850 fewer per 1,000 (from 910 fewer to 740 fewer)	⊕⊕⊕○ Moderate <sup>a,b,c</sup>	CRITICAL

MHZC, micro-hole zone catheters; CI, confidence interval; RR, risk ratio. Explanations: a. limited sample size, b. industry sponsorship, c. hematuria used as a proxy for trauma