GUIDELINE FOR PREVENTION OF CATHETER-ASSOCIATED URINARY TRACT INFECTIONS

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The guidelines were developed from a systematic review of the currently available evidence on CA-UTI. Our goal was to develop a targeted systematic review based on the best available evidence with explicit links between the literature reviewed and the final recommendations. Our guideline development process is outlined in *Figure 1.*

Study Selection

An electronic search of the National Guideline Clearinghouse, Medline, the Cochrane Health Technology Assessment Database, the NIH Consensus Development Program, and the United States Preventative Services Task Force database was conducted for existing national and international guidelines. The strategy used for the guideline search and the search results can be found in *Appendix 1A.* A preliminary list of key questions was developed from a review of the relevant guidelines identified in the

search. Key questions were finalized after vetting them with HICPAC members. Following this, search terms were developed for identifying literature relevant to the key questions. For the purposes of quality assurance, we compared these terms to those used in relevant seminal studies and guidelines. These search terms were then incorporated into search strategies for the relevant electronic databases. Searches were performed in Medline, EMBASE, CINAHL and Cochrane, and the resulting references were imported into a reference manager where duplicates were resolved. The detailed search strategy used for identifying primary literature and the results of the search can be found in *Appendix 1B*.

Titles and abstracts from references were screened by a single author and the full text articles were retrieved if they were 1) relevant to one or more key questions, 2) primary analytic research, systematic reviews or meta-analyses, and 3) written in English. Likewise, the full-text articles were screened by a single author using the same criteria, and included studies underwent data abstraction. Disagreements in the abstract or full-text screening were resolved by the remaining authors. The results of this process are depicted in *Figure 2.*

Data Extraction and Synthesis

Data on the study author, year, design, objective, population, setting, sample size, power, follow up, and definitions and results of clinically relevant outcomes were abstracted into evidence tables. Three evidence tables were developed, each of which represented one of our key questions. Studies were extracted into the most relevant evidence table. Then, studies were organized by the common themes that emerged within each evidence table. Data were extracted by one author and cross-checked by another. Disagreements were resolved by the remaining authors. Only original data was included in the evidence tables. Quantitative analyses including statistical tests of significance and meta-analyses were not performed. Systematic reviews were included in our review. We excluded primary studies originally identified by our systematic search if they were also included in a systematic review captured by our search. The only exception to this was if the primary study also addressed a relevant question that was outside the scope of the systematic review. To ensure that all relevant studies

were captured in the search, the bibliography was vetted by a panel of clinical experts. For the purposes of our review, statistical significance was defined as $P \leq 0.05$.

Grading of Evidence

First, the quality of each study was assessed using scales adapted from existing methodology checklists, and scores were recorded in the evidence tables. *Appendix 3* includes the sets of questions we used to assess the quality of each of the major study designs. Next, the quality of the evidence base was assessed using methods adapted from the GRADE Working Group. Briefly, GRADE tables were developed for each of the themes within the evidence tables. Included within the GRADE tables were the intervention of interest, any outcomes listed in the evidence tables that were judged to be clinically important, the quantity and type of evidence for each outcome, the relevant findings, and the GRADE of evidence for each outcome, as well as an overall GRADE of the evidence base for the given intervention. The initial GRADE of evidence for each outcome was deemed high if the evidence base included an RCT or a systematic review of RCTs, low if the evidence base included only observational studies, or very low if the evidence base consisted only of expert opinion or uncontrolled studies. The initial GRADE could then be modified by eight criteria. Criteria which could decrease the GRADE included quality, consistency, directness, precision, and publication bias. Criteria that could increase the GRADE included a large magnitude of effect, a dose-response gradient, or inclusion of unmeasured confounders that would increase the magnitude of effect (*Table 1*). GRADE definitions are as follows:

1. High - further research is very unlikely to change confidence in the estimate of effect
2. Moderate - further research is likely to impact confidence in the estimate of effect and may change the estimate
3. Low - further research is very likely to impact confidence in the estimate of effect and is likely to change the estimate
4. Very low - any estimate of effect is very uncertain

Once the GRADE of the evidence base for each outcome of a given intervention was determined, the overall GRADE of the evidence base for that intervention was

calculated. The overall GRADE was based on the lowest GRADE for the outcomes deemed critical to making a recommendation.

Formulating Recommendations

Recommendations were drafted from the GRADE tables. Factors determining the strength of a recommendation included 1) the values and preferences we used to determine which outcomes were "critical," 2) the risks and benefits that result from weighing the "critical" outcomes, and 3) the overall GRADE of the evidence base for the given intervention.

Category I recommendations were defined as strong recommendations. The implications of a strong recommendation are (ref):

1. For patients - most people in your situation would want the recommended course of action and only a small proportion would not; request discussion if the intervention is not offered
2. For clinicians - most patients should receive the recommended course of action
3. For policymakers - the recommendation can be adopted as a policy in most situations

Category II recommendations were defined as weak recommendations and the implications of such a recommendation are (ref):

1. For patients - most people in your situation would want the recommended course of action, but many would not
2. For clinicians - you should recognize that different choices will be appropriate for different patients and that you must help each patient to arrive at a management decision consistent with her or his values and preferences
3. For policymakers - policy making will require substantial debate and involvement of many stakeholders

Recommendations were cross-checked with those from guidelines identified in our systematic search. They were then vetted by HICPAC. Our recommendations focused

only on efficacy, effectiveness and safety. The optimal use of these guidelines would include a consideration of the costs relevant to the users local setting.

Type of evidence	**Initial grade**	**Criteria to decrease grade**	**Criteria to increase grade**	**Overall quality grade**
RCT	High	Quality Serious (-1) or very serious (-2) limitation to study quality	Strong Association Strong (+1) or very strong evidence of association (+2)	High Moderate
Observational study	Low	Consistency Important inconsistency (-1)	Dose-response Evidence of a dose-response gradient (+1)	Low
Any other evidence (e.g. expert opinion)	Very low	Directness Some (-1) or major (-2) uncertainty about directness	Confounders Inclusion of unmeasured confounders increases the magnitude of effect (+1)	Very Low
		Precision Imprecise or sparse data (-1)		
		Publication Bias High risk of bias (-1)		

Table 1: Rating the Quality of Evidence using the GRADE Approach

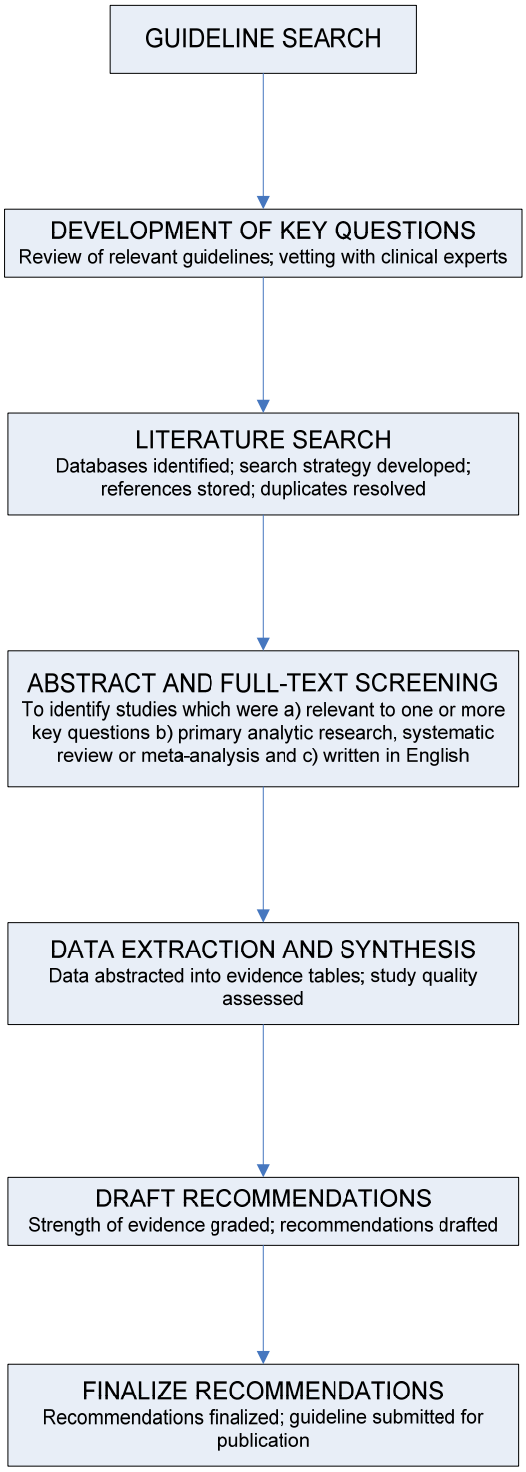

Figure 1: The Guideline Development Process

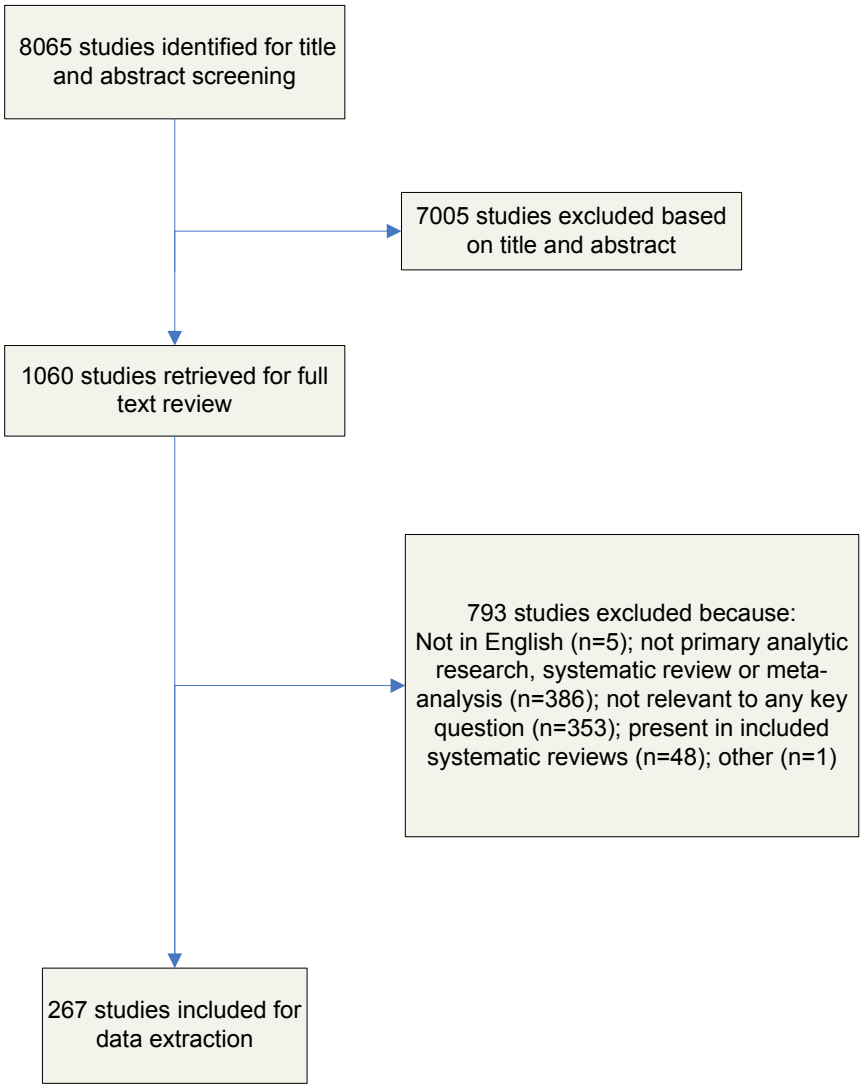

Figure 2: Results of the study selection process (April 2008)

V. Evidence Review

Q1. Who should receive urinary catheters?

To answer this question, we focused on three subquestions: A) Is urinary catheterization necessary? B) What are the risk factors for CA-UTI? and C) What populations are at highest risk of mortality from urinary catheters?

A. Is urinary catheterization necessary?

The available data examined five main populations. In all populations, we considered CA-UTI outcomes as well as other outcomes we deemed critical to weighing the risks and benefits of catheterization. The findings of the evidence review and the grades for all important outcomes are shown in *Table 1A*

In *operative patients*, there was low quality evidence to suggest a benefit of not using urinary catheters routinely. This was based on a decreased risk of bacteriuria/unspecified UTI, no effect on bladder injury, and increased risk of urinary retention or recatheterization in patients not receiving catheters. The increased risk of urinary retention and recatherization in patients without catheters was specifically seen following urogenital surgeries. The most common surgeries studied were urogenital, gynecological, laparoscopic, and orthopaedic surgeries. Our search did not reveal data on the impact of catheterization on peri-operative hemodynamic management.

In *incontinent patients*, there was low quality evidence to suggest a benefit of not using urinary catheters. This was based on a decreased risk of both symptomatic UTI and bacteriuria/unspecified UTI in male nursing home residents without urinary catheters compared to those with continuous condom catheters. No difference in the risk of UTI was found between having a condom catheter at night only and having no catheter. Our search did not reveal data on the impact of catheterization on skin breakdown.

In *patients with bladder outlet obstruction*, very low quality evidence suggested a benefit of a urethral stent over an indwelling catheter. This was based on a reduced risk of bacteriuria in those receiving a urethral stent. Our search did not reveal data on the impact of catheterization versus stent placement on urinary complications.

In *patients with spinal cord injury*, very low quality evidence suggested a benefit of not using indwelling urinary catheters. This was based on a decreased risk of symptomatic UTI and bacteriuria in those not using indwelling urinary catheters (including patients managed with spontaneous voiding, clean intermittent catheterization (CIC), and external striated sphincterotomy with condom catheter drainage), as well as a lower risk of urinary complications, including hematuria, stones, and urethral injury (fistula, erosion, stricture).

In *children with myelomeningocele and neurogenic bladder*, very low quality evidence suggested a benefit of CIC compared to urinary diversion or self voiding. This was based on a decreased risk of bacteriuria/unspecified UTI in patients receiving CIC compared to urinary diversion, and a lower risk of urinary tract deterioration (defined by febrile urinary tract infection, vesicoureteral reflux, hydronephrosis, or increases in BUN or serum creatinine) with CIC compared to self-voiding and in those receiving CIC early (< 1 year of age) versus late (> 3 years of age).

1.A.1. Use urinary catheters in operative patients only as necessary, rather than routinely, weighing the risks of infection, the risks of urinary retention, and the need for intraoperative catheterization. **(Category II)**

1.A.2. Avoid urinary catheterization of patients and nursing home residents for management of incontinence. **(Category II)** Further study is needed on periodic use of condom catheters in this population and the use of catheters to prevent skin breakdown. **(No recommendation/unresolved issue)**

1.A.3. Use alternative urinary drainage strategies to chronic indwelling catheters in spinal cord injury patients whenever possible. **(Category II)**

1.A.4. Use clean intermittent catheterization in children with myelomeningocele and neurogenic bladder to reduce the risk of urinary tract deterioration. **(Category II)**

1.A.5. Further study is needed on the benefit of using a urethral stent as an alternative to an indwelling catheter in selected patients with bladder outlet obstruction. **(No recommendation/unresolved issue)**

B. What are the risk factors for CA-UTI?

To answer this question, we reviewed the quality of evidence for those risk factors examined in more than one study. We considered the critical outcomes for decision-making to be symptomatic UTI and bacteriuria. The findings of the evidence review and the grades for all important outcomes are shown in *Table 1B*

For *symptomatic UTI*, low-quality evidence suggested that female sex, older age, prolonged catheterization, impaired immunity, and lack of antimicrobial exposure are risk factors. For *bacteriuria*, multiple risk factors were identified; there was high quality evidence for prolonged catheterization and moderate quality evidence for female sex and lack of antimicrobial exposure. Low quality evidence suggested that older age, disconnection of the drainage system, diabetes, renal dysfunction, higher severity of illness, placement of the catheter outside of the operating room, lower professional training of the person inserting the catheter, and incontinence as a reason for catheterization were risk factors for bacteriuria. Our search did not reveal data on adverse events and antimicrobial resistance associated with antimicrobial use, although one observational study found that the protective effect of antimicrobials lasted only for the first four days of catheterization, and that antimicrobial exposure led to changes in the epidemiology of bacterial flora in the urine.

1.B.1. Maintain a sterile, continuously closed drainage system **(Category IA)**

1.B.2. Do not disconnect the catheter and urinary drainage system unless the catheter must be irrigated **(Category IA)**

1.B.3. Leave catheters in place only as long as needed for appropriate indications **(Category IA)**

1.B.4. Minimize urinary catheter use and duration of use in patients at higher risk for CA-UTI such as women, the elderly, and patients with impaired immunity, higher severity of illness, diabetes, renal dysfunction, and incontinence. **(Category II)**

1.B.5. Ensure that only properly trained personnel insert urinary catheters using correct aseptic technique. **(Category II)**

C. What populations are at highest risk of mortality from urinary catheters?

To answer this question, we reviewed the quality of evidence for those risk factors examined in more than one study. The findings of the evidence review and the grades for all important outcomes are shown in *Table 1C*

There was low quality evidence to suggest that older age, higher severity of illness, and being on an internal medicine service compared to a surgical service were independent risk factors for mortality in patients with indwelling urinary catheters. Both studies evaluating these risk factors found the highest risk of mortality in patients over 70 years of age. Low quality evidence also suggested that CA-UTI was a risk factor for mortality in patients with catheters.

1.C.1. Minimize urinary catheter use and duration in patients who may be at higher risk for mortality due to catheterization, such as the elderly and patients with higher severity of illness **(Category II)**

Q2. For those who may require urinary catheters, what are the best practices?

To answer this question, we focused on four subquestions: A) What are the risks and benefits associated with different approaches to catheterization? B) What are the risks and benefits associated with different types of catheters or collecting systems? C) What catheter management techniques reduce the risk of infection and D) What systems changes reduce the risk of infection?

A. What are the risks and benefits associated with different approaches to catheterization?

The available data examined the following comparisons of different catheterization approaches:

1) Condom versus indwelling
2) Intermittent versus indwelling
3) Suprapubic versus indwelling urethral
4) Suprapubic versus intermittent
5) Clean intermittent versus sterile intermittent

For all comparisons, we considered CA-UTI outcomes of symptomatic UTI, bacteriuria/unspecified UTI, or combinations of these outcomes depending on availability, as

well as other outcomes critical to weighing the risks and benefits of different catheterization approaches. The findings of the evidence review and the grades for all important outcomes are shown in *Table 2A*

1. Condom versus indwelling

There was moderate quality evidence to support the use of condom catheters over indwelling catheters in male patients who require a urinary collection device but do not have an indication for an indwelling catheter such as urinary retention or bladder outlet obstruction. This was based on a decreased risk of a composite outcome of symptomatic UTI, bacteriuria, or death as well as increased patient satisfaction with condom catheters. Differences were most pronounced in men without dementia. Statistically significant differences were not found or reported for the individual CA-UTI outcomes or death. Our search did not reveal data on differences in local complications such as skin maceration or phimosis.

2. Intermittent versus indwelling

There was low quality evidence to support the use of intermittent catheterization over an indwelling catheter in selected populations. This was based on a decreased risk of symptomatic UTI and bacteriuria/unspecified UTI but an increased risk of urinary retention in post-operative patients with intermittent catheterization. In one study, urinary retention and bladder distension were avoided by performing catheterization at regular intervals (every 6-8 hrs) until return of voiding. Studies of patients with neurogenic bladder most consistently found a decreased risk of CA-UTI with intermittent catheterization. Studies in operative patients with the shortest time to removal of indwelling catheters (within 24 hrs of surgery) found no differences in bacteriuria, while studies where catheters were left in for longer periods of time had mixed results. Our search did not reveal data on differences in patient satisfaction or willingness/ability to perform intermittent self-catheterization.

3. Suprapubic versus indwelling urethral

There was low quality evidence to support the use of suprapubic catheters over indwelling catheters in selected populations. This was based on a decreased risk of bacteriuria/unspecified UTI, recatheterization, and urethral stricture, and increased patient comfort and satisfaction. However, there were no differences in symptomatic UTI and an increased risk of longer duration of catheterization with suprapubic catheters. Studies involved primarily post-operative and spinal cord injury patients. Our search did not reveal data on differences in complications related to catheter insertion or the catheter site.

4. Suprapubic versus intermittent

There was very low quality evidence to support the use of intermittent over suprapubic catheterization in selected populations based on increased patient acceptability and decreased risk of urinary complications (bladder calculi, vesicoureteral reflux, and upper tract abnormalities). Although there was a decreased risk of bacteriuria/unspecified UTI with suprapubic catheterization, there were no differences in symptomatic UTI. The populations studied included women undergoing urogynecologic surgery and spinal cord injury patients.

5. Clean intermittent versus sterile intermittent

There was moderate quality evidence to suggest no differences in the risk of symptomatic UTI or bacteriuria/unspecified UTI between clean intermittent and sterile intermittent catheterization technique. Study populations included nursing home patients and adults and children with neurogenic bladder/spinal cord injury.

2.A.1. Condom catheter drainage is preferable to an indwelling urethral catheter in cooperative male patients without urinary retention or bladder outlet obstruction. **(Category IB)**

2.A.2. Intermittent catheterization is preferable to an indwelling urethral or suprapubic catheter in selected patients with bladder emptying dysfunction. Intermittent catheterization should be performed at regular intervals to prevent urinary retention. **(Category II)**

2.A.3. For operative patients who have an indication for an indwelling catheter, remove the catheter as soon as possible post-operatively, preferably within 24 hours. **(Category II)***

2.A.4. Further study is needed on the risks and benefits of suprapubic catheters as an alternative to indwelling urethral catheters in selected patients requiring short or long-term catheterization, particularly with respect to patient preference and complications related to catheter insertion or the catheter site. **(No recommendation/unresolved issue)**

2.A.5. Clean intermittent catheterization is an acceptable and more practical alternative to sterile intermittent catheterization for patients requiring chronic intermittent catheterization. **(Category IB)**

* More data in other section on removal of catheters

B. What are the risks and benefits associated with different catheters or collecting systems?

The available data examined the following comparisons between different types of catheters and drainage systems:

1. Silver-coated catheters vs. standard catheters
2. Antibiotic-coated catheters vs. standard catheters
3. Hydrophilic catheters vs. standard catheters
4. Closed vs. open drainage systems
5. Complex vs. simple drainage systems
6. Preconnected/sealed junction catheters vs. standard catheters
7. Catheter valves vs. catheter bags

For all comparisons, we considered CA-UTI outcomes as well as other outcomes critical to weighing the risks and benefits of different types of catheters or collecting systems. The findings of the evidence review and the grades for all important outcomes are shown in *Table 2B*

1. Silver-coated catheters vs. standard catheters

There was low-quality evidence to support the use of silver-coated catheters over standard catheters. This was based on a decreased risk of CA-UTI with silver-coated catheters and no

evidence of increased urethral irritation or discharge or antimicrobial resistance. There was higher quality evidence for the outcome of bacteriuria/unspecified UTI than symptomatic UTI. The one study that found a decrease in symptomatic UTI with silver alloy-coated catheters was done in a burn referral center, where the control catheters were latex, and patients in the intervention group had new catheters placed on admission, whereas the control group did not. In systematic reviews, differences were significant for silver alloy-coated catheters but not silver oxide-coated catheters. The effect of silver alloy catheters was more pronounced when the control catheter was latex rather than silicone and when used in patients catheterized < 1 week. Several recent studies in hospitalized patients found no effect of silver alloy-coated catheters.

2. Antibiotic-coated catheters vs. standard catheters

There was low-quality evidence to suggest a benefit of antibiotic-coated catheters in patients catheterized for short periods of time. This was based on a decreased risk of bacteriuria and no evidence of increased antimicrobial resistance. The one study demonstrating a decreased risk of bacteriuria did so if duration of catheterization was < 1 week, but not if duration was > 1 week, in in men post radical prostatectomy who received a silicone catheter impregnated with minocycline and rifampin versus a standard silicone catheter. Other studies found no differences in bacteriuria or symptomatic UTI with antibiotic-coated catheters compared to standard catheters.

3. Hydrophilic catheters vs. standard catheters

There was very low-quality evidence to support the use of hydrophilic catheters over standard non-hydrophilic catheters in specific populations undergoing clean intermittent catheterization. This was based on a decreased risk of symptomatic UTI, bacteriuria, hematuria, and pain during insertion, and increased patient satisfaction. Differences in CA-UTI outcomes were limited to one study of spinal cord injury patients and one study of patients receiving intravesical immunochemoprophylaxis for bladder cancer, while multiple other studies found no significant differences.

4. Closed vs. open drainage systems

There was very low quality evidence to support the use of a closed rather than open urinary drainage system based on a decreased risk of bacteriuria and a suggestion in one study of an increased risk of symptomatic UTI, bacteremia, and UTI-related mortality associated with open drainage systems.. A seminal study from 1966 (Ref Kunin, McCormack) demonstrating the benefit of a sterile, closed drainage system was excluded from the evidence review because it lacked a control group; however, because of the finding that this measure alone could reduce the rate of infection with short term catheterization from a historical 100% with opened drainage to less than 25%, sterile, continuously closed drainage systems have been adopted as standard practice. Recent data supporting this recommendation includes the finding that disconnection of the drainage system is a risk factor for CA-UTI.

5. Complex vs. simple drainage systems

There was low quality evidence to suggest a benefit of complex closed urinary drainage systems over simple closed urinary drainage systems. This was based on a decreased risk of bacteriuria. Differences were found only in studies published before 1990, and not in more recent studies. The complex drainage systems studied included several methods to block

bacterial entry at the urethral insertion site, the catheter drainage tube junction, and the outflow tube.

6. Preconnected/sealed junction catheters vs. standard catheters

There was low quality evidence to support the use of preconnected catheters with junction seals over catheters with unsealed junctions. This was based on a decreased risk of symptomatic UTI and bacteriuria with preconnected sealed catheters. Studies that found differences had higher rates of CA-UTI in the control group than studies that did not find an effect.

7. Catheter valves vs. catheter bags

There was moderate quality evidence to suggest a benefit of catheter valves over drainage bags in selected patients with indwelling urinary catheters. This was based on increased patient satisfaction and no differences in bacteriuria/unspecified UTI or pain/bladder spasms with catheter valves. Details regarding the setting for recruitment and follow-up of the patients in the studies were unclear, and the majority of subjects were men. Our search did not reveal data on the effect of catheter valves on bladder function, bladder/urethral trauma, or catheter blockage.

2.B.1. Further study is needed on the benefit of antimicrobial (silver alloy- or antibiotic-coated) catheters compared to standard silicone based catheters in reducing the risk of clinically significant CA-UTI events. **(No recommendation/unresolved issue)**

2.B.2. Hydrophilic catheters are preferable to standard catheters for patients requiring intermittent catheterization. **(Category II)**

2.B.3. Maintain a sterile, continuously closed drainage system **(Category IA)**

2.B.4. Complex urinary drainage systems are not needed as a routine prevention measure for CA-UTI. **(Category II)**

2.B.5. The use of urinary catheters with preconnected sealed junctions is a useful adjunct measure to reduce the risk of disconnection of the sterile closed drainage system. **(Category II)**

2.B.6. Further study is needed to clarify the benefit of catheter valves in reducing the risk of CA-UTI and other urinary complications as well as the appropriate patient population for this device. **(No recommendation/unresolved issue)**

C. What are the risks and benefits associated with the different catheter management techniques?

D. What are the risks and benefits associated with the different systems changes?

Question 3: What are the best methods to manage catheter-associated complications?

A. What are the best methods to manage an obstructed urinary catheter?

VI. Implementation and Audit

1. Discuss organizational barriers and cost implications of the guideline
2. Discuss key review criteria for monitoring and/or audit purposes

VII. Recommendations for Further Research

GRADE Tables

Question 1: Who should receive urinary catheterization?

A. Is urinary catheterization necessary?

Table 1A

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
Catheter vs. no catheter for operative patients	Symptomatic UTI*	2 RCT [2, 7]	2 RCTs did not report statistical differences [2, 7]	High	0	0	-1	-1	0	0	0	0	Low	Low
	Bacteriuria/ Unspecified UTI*	1 SR [1] 7 RCT [2-8] 3 OBS [9-11]	1 SR showed no significant differences [1] . 1 RCT [7] and 1 OBS [11] showed a significantly decreased risk with no catheterization. The other RCTs [2-6, 8] and the 2 OBS [9, 10] showed no significant differences, although there was some suggestion of increased risk with catheterization in higher quality studies	High	-1	0	0	0	0	0	0	0	Moderate	
	Urinary Retention*	1 SR [1] 1 RCT [4] 1 OBS [9]	The SR showed a significantly decreased risk of urinary retention with catheterization [1] . In the RCT, no significant differences were found [4] and in the OBS [9] , statistical differences were not reported.	High	-1	-1	0	0	0	0	0	0	Low	
	Recatheterization*	1 SR [1] 3 RCT [2, 5, 6] 1 OBS [10]	The SR showed a significantly decreased risk of recatheterization with the use of a urinary catheter [1] . 3 RCTs showed no significant differences [2, 5, 6] . In the OBS, comparative data were not provided.	High	0	-1	0	-1	0	0	0	0	Low	
	Length of Stay/Hospitalization	1 RCT [3]	No significant differences were found	High	-1	0	0	-1	0	0	0	0	Low	

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
	Bladder injury*	1 RCT [2] 1 OBS [10]	There were no events in either group in both studies	High	0	0	0	-1	-1	0	0	0	Low	
Catheter vs. no catheter for incontinent patients	Symptomatic UTI*	1 OBS [13]	Having no catheter had a significantly reduced risk compared with wearing the catheter continuously.	Low	0	0	0	0	0	0	0	0	Low	Low
	Bacteriuria/Unspecified UTI*	1 RCT [12] 2 OBS [13, 14]	In 1 OBS, having no catheter had a significantly reduced risk compared with wearing the catheter continuously. No significant differences were found between having a catheter at night only and having no catheter [13] . In the other OBS, all patients in both groups had bacteriuria [14] . Statistical differences were not reported in the RCT [12] .	High	-1	-1	0	0	0	0	0	0	Low	
	Mortality	1 OBS [15]	Statistical differences were not reported	Low	0	0	0	-1	0	0	0	0	Very Low	
	Nursing time	1 RCT [12]	Statistical differences were not reported	High	-1	0	0	-1	0	0	0	0	Low	
Catheter vs. stent for bladder outlet obstruction	Symptomatic UTI*	1 OBS [16]	Statistical differences were not reported; although there was a suggestion that stent was better than catheter	Low	0	0	0	-1	0	0	0	0	Very Low	Very Low
	Bacteriuria*	1 OBS [16]	There was an increased risk of bacteriuria with the use of indwelling catheter	Low	0	0	0	0	0	0	0	0	Low	
Catheter vs. no catheter for spinal cord injury patients	Symptomatic UTI*	2 OBS [17, 18]	Significantly reduced with no catheterization in both studies	Low	0	0	0	0	0	0	0	0	Low	Very Low
	Bacteriuria*	1 OBS [17]	Significantly reduced with no catheterization	Low	0	0	0	-1	0	0	0	0	Very Low	
	Urinary complications*	1 OBS [18]	Significantly reduced with no catheterization	Low	0	0	0	-1	0	0	0	0	Very Low	
	Mortality	1 OBS [18]	Statistical differences were not reported	Low	0	0	0	-1	0	0	0	0	Very Low	
Catheter vs. no catheter for children with neurogenic	Symptomatic UTI*	1 OBS [21]	No significant differences were found	Low	0	0	0	-1	0	0	0	0	Very Low	Very Low
	Bacteriuria/ Unspecified UTI*	2 OBS [20,	Ileal loop diversion had a significantly greater risk when compared	Low	0	0	-1	0	0	0	0	0	Very Low	

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
bladder		[21]	with clean intermittent catheterization in 1 OBS [21] . There were no significant differences in early vs. late clean intermittent catheterization in the other OBS [20] .											
	Urinary tract deterioration/Hydronephrosis*	1 RCT [19] 1 OBS [20]	Clean intermittent catheterization significantly reduced urinary tract deterioration in the RCT [19] and when used early as in the OBS [20]	High	-1	0	-1	0	0	0	0	0	Low	

* These modifiers can impact the GRADE by 1 or 2 points

B. What are the risk factors for CA-UTI?

Table 1B

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
Old age	Symptomatic UTI*	5 OBS [13, 17, 26, 31, 46]	Independent risk factor in 1 OBS [26] , possible risk factor in 1 OBS [17] Not found to be a risk factor in 3	Low	0	0	0	0	0	0	0	0	Low	Low

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
			OBS [13, 31, 46]											
	Bacteriuria*	11 OBS [24, 27, 28, 30, 34, 37-41, 44]	Possible risk factor in 2 OBS [38, 39] Not found to be a risk factor in 9 OBS [24, 27, 28, 30, 34, 37, 40, 41, 44]	Low	0	0	0	0	0	0	0	0	Low	
Female sex	Symptomatic UTI*	4 OBS [17, 25, 26, 46]	Independent risk factor in 1 OBS [26] Not found to be a risk factor in 3 OBS [17, 25, 46]	Low	0	0	0	0	0	0	0	0	Low	Low
	Bacteriuria*	11 OBS [24, 27, 28, 33, 34, 37-41, 44]	Independent risk factor in 4 OBS [27, 28, 34, 38], possible risk factor in 2 OBS [33, 44] Not found to be a risk factor in 5 OBS [24, 37, 39-41]	Low	0	0	0	0	0	+1	0	0	Moderate	
Prolonged duration of catheterization	Symptomatic UTI*	2 OBS [17, 25]	Independent risk factor in 1 OBS [17], possible risk factor in 1 OBS [25]	Low	0	0	0	0	0	0	0	0	Low	Low
	Bacteriuria*	8 OBS [27, 28, 30, 34, 37-39, 41]	Independent risk factor in 5 OBS [27, 28, 37-39], possible risk factor in 3 OBS [30, 34, 41]	Low	0	0	0	0	0	+1	+1	0	High	
Lack of administration of antibiotics	Symptomatic UTI*	4 OBS [13, 17, 25, 31]	Independent risk factor in 1 OBS [25] Not found to be a risk factor in 3 OBS [13, 17, 31]	Low	0	0	0	0	0	0	0	0	Low	Low
	Bacteriuria*	9 OBS [24, 27, 28, 34, 37-39, 41, 44]	Independent risk factor in 6 OBS [27, 28, 34, 37-39], possible	Low	0	0	0	0	0	+1	0	0	Moderate	

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
			risk factor in 2 OBS [41, 44] Not found to be a risk factor in 1 OBS [24]											
Impaired immunity	Symptomatic UTI*	2 OBS [17, 25]	Independent risk factor in 1 OBS [25] Not found to be a risk factor in 1 OBS [17]	Low	0	0	0	0	0	0	0	0	Low	Very Low
	Bacteriuria*	1 OBS [29] 1 OBS [28]	Independent risk factor in 1 OBS [29] Not found to be a risk factor in 1 OBS [28]	Low	0	-1	0	0	0	0	0	0	Very Low	
Disconnection of the drainage system	Bacteriuria*	4 OBS [30, 37, 38, 41]	Independent risk factor in 1 OBS [30] , possible risk factor in 1 OBS [38] Not found to be a risk factor in 2 OBS [37, 41]	Low	0	0	0	0	0	0	0	0	Low	Low
Diabetes	Symptomatic UTI*	2 OBS [13, 31]	Not found to be a risk factor in 2 OBS [13, 31]	Low	0	0	0	-1	0	0	0	0	Very Low	Very Low
	Bacteriuria*	2 OBS [28, 38]	Independent risk factor in 1 OBS [38] Not found to be a risk factor in 1 OBS [28]	Low	0	0	0	0	0	0	0	0	Low	
Renal dysfunction	Symptomatic UTI*	2 OBS [13, 31]	Not found to be a risk factor in 2 OBS [13, 31]	Low	0	0	0	-1	0	0	0	0	Very Low	Very Low
	Bacteriuria*	3 OBS [34, 38, 39]	Independent risk factor in 2 OBS [34, 38] Not found to be a risk factor in 1	Low	0	0	0	0	0	0	0	0	Low	

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
			OBS [39]											
Surgical illness	Bacteriuria*	2 OBS [40, 44]	Possible risk factor in 1 OBS [40] Not found to be a risk factor in 1 OBS [44]	Low	0	0	0	0	-1	0	0	0	Very Low	Very Low
Severity of illness	Bacteriuria*	5 OBS [27, 28, 38, 40, 44]	Independent risk factor in 1 OBS [27] , possible risk factor in 1 OBS [44] Not found to be a risk factor in 3 OBS [28, 38, 40]	Low	0	0	0	0	0	0	0	0	Low	Low
Orthopedic population	Bacteriuria*	2 OBS [37, 39]	Independent risk factor in 2 OBS [37, 39]	Low	0	0	0	0	0	0	0	0	Low	Low
Neurology population	Bacteriuria*	3 OBS [28, 37, 39]	Independent risk factor in 1 OBS [37] , possible risk factor in 1 OBS [39] Not found to be a risk factor in 1 OBS [28]	Low	0	0	0	0	0	0	0	0	Low	Low
Intensive care unit	Bacteriuria*	2 OBS [39, 44]	Not found to be a risk factor in 2 OBS [39, 44]	Low	0	0	0	0	0	0	0	0	Low	Low
Catheter insertion outside of operating room	Bacteriuria*	2 OBS [37, 39]	Independent risk factor in 1 OBS [39] Not found to be a risk factor in 1 OBS [37]	Low	0	0	0	0	0	0	0	0	Low	Low
Person performing catheterization – Nurse vs. MD or LPN vs. (RN or	Bacteriuria*	3 OBS [37, 38, 44]	Possible risk factor in 2 OBS [38, 44] Not found to be a risk factor in 1 OBS [37]	Low	0	0	0	0	0	0	0	0	Low	Low

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
MD)														
Incontinence as a reason for catheterization	Bacteriuria*	2 OBS [37, 39]	Independent risk factor in 1 OBS [37] , possible risk factor in 1 OBS [39]	Low	0	0	0	0	0	0	0	0	Low	Low
Catheter blockage	Symptomatic UTI*	2 OBS [31, 45]	Possible risk factor in 1 OBS [45] Not found to be a risk factor in 1 OBS [31]	Low	0	0	0	-1	0	0	0	0	Very Low	Very Low
Low albumin level	Symptomatic UTI*	2 OBS [13, 31]	Possible risk factor in 2 OBS [13, 31]	Low	0	0	0	-1	0	0	0	0	Very Low	Very Low
Low hemoglobin level	Symptomatic UTI*	2 OBS [13, 31]	Not found to be a risk factor in 2 OBS [13, 31]	Low	0	0	0	-1	0	0	0	0	Very Low	Very Low
Stool incontinence	Symptomatic UTI*	2 OBS [13, 31]	Not found to be a risk factor in 2 OBS [13, 31]	Low	0	0	0	-1	0	0	0	0	Very Low	Very Low
Urinary acidifier	Symptomatic UTI*	2 OBS [13, 31]	Not found to be a risk factor in 2 OBS [13, 31]	Low	0	0	0	-1	0	0	0	0	Very Low	Very Low
Race (non-white vs. white)	Bacteriuria*	2 OBS [24, 38]	Possible risk factor in 2 OBS [24, 38]	Low	0	0	0	-1	0	0	0	0	Very Low	Very Low

* These modifiers can impact the GRADE by 1 or 2 points
Definitions: “Independent risk factor” implies it was significant in a multivariate analysis, “possible risk factor” implies it was significant in a univariate analysis

C. What populations are at highest risk of mortality from urinary catheters?

TABLE 1C

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
Old age	Mortality*	2 OBS [25, 47]	Independent risk factor in 2 OBS [25, 47]	Low	0	0	0	0	0	0	0	0	Low	Low
Severity of illness	Mortality*	2 OBS [25, 47]	Independent risk factor in 2 OBS [25, 47]	Low	0	0	0	0	0	0	0	0	Low	Low
Internal medicine (vs. surgery)	Mortality*	2 OBS [25, 47]	Independent risk factor in 2 OBS [25, 47]	Low	0	0	0	0	0	0	0	0	Low	Low
Administration of antibiotics	Mortality*	2 OBS [25, 47]	Administration of antibiotics was an independent risk factor in 1 OBS [25] and lack of administration of antibiotics was a possible risk factor in 1 OBS [47]	Low	0	-1	0	0	0	0	0	0	Very Low	Very Low
CA-UTI	Mortality*	2 OBS [25, 47]	Independent risk factor in 1 OBS [47] Not found to be a risk factor in 1 OBS [25]	Low	0	0	0	0	0	0	0	0	Low	Low

* These modifiers can impact the GRADE by 1 or 2 points

Definitions: “Independent risk factor” implies it was significant in a multivariate analysis, “possible risk factor” implies it was significant in a univariate analysis

Question 2: For those who may require urinary catheters, what are the best practices?

A. What are the risks and benefits associated with different approaches to catheterization?

Table 2A

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
Condom vs. indwelling catheterization	Bacteriuria, symptomatic UTI or death*	1 RCT [48]	Significantly increased risk with indwelling catheterization, particularly in men without dementia	High	0	0	0	-1	0	0	0	0	Moderate	Moderate
	Bacteriuria*	1 RCT [48]	No significant differences were found	High	0	0	0	-1	0	0	0	0	Moderate	
	Bacteremia	1 OBS [49]	No significant differences were found	Low	0	0	0	-1	0	0	0	0	Very Low	
	Mortality	1 RCT [48]	Statistical differences were not reported	High	-1	0	0	-1	0	0	0	0	Low	
	Patient satisfaction*	1 RCT [48] 1 OBS [50]	Significantly increased comfort and decreased pain with condom catheterization in both studies. Also a significant decrease in restriction in the OBS [50]	High	0	0	0	0	0	0	0	0	High	
Intermittent vs. indwelling catheterization	Symptomatic UTI*	2 RCT [52, 53] 1 OBS [83]	Significantly decreased risk of pyelonephritis with intermittent catheterization 1 RCT [53] and 1 OBS [83] . No significant differences were found in the other RCT [52]	High	-2	0	0	0	0	0	0	0	Low	Low
	Bacteriuria/Unspecified UTI*	3 SR [51, 61, 62] 4 RCT [52, 54-56] 5 OBS [57-60, 84]	Significantly decreased risk with intermittent catheterization in 1 SR [51] . 2 SRs noted a decreased risk with intermittent catheterization, but statistical differences were not reported [61, 62] . No significant differences were found in 4 RCTs [52, 54-56] and 4 OBS [58-60, 84] . Statistical differences were not reported in 1 OBS [57]	High	0	0	-1	0	0	0	0	0	Moderate	
	Bacteremia	1 RCT [53]	No significant differences were found	High	-1	0	0	-1	0	0	0	0	Low	

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
	Urinary retention*	1 SR [51] 4 RCT [52, 54-56] 1 OBS [58]	Significantly increased risk with intermittent catheterization in 1 RCT [56] and 1 OBS [58] . and decreased risk in 1 RCT [55] . Suggestions of increased risk were found in 1 SR [51] and 2 RCTs [52, 54] , although no significant differences were reported.	High	0	-1	0	0	0	0	0	0	Moderate	
	Calculi	2 OBS [83, 84]	Significantly decreased risk of upper tract calculi with intermittent catheterization, but no significant differences in bladder calculi in 1 OBS [83] . No significant differences in upper or lower tract calculi were found in the other OBS [84]	Low	-1	0	0	0	0	0	0	0	Very Low	
	Stricture	1 OBS [83]	Significantly decreased risk with intermittent catheterization	Low	-1	0	0	0	0	0	0	0	Very Low	
	Vesicoureteral reflux	1 OBS [83]	Significantly decreased risk with intermittent catheterization	Low	-1	0	0	0	0	0	0	0	Very Low	
	Mortality	1 RCT [55]	Statistical differences were not reported	High	-1	0	0	-1	0	0	0	0	Low	
Suprapubic vs. indwelling urethral catheterization	Symptomatic UTI*	1 SR [51] 1 RCT [65] 1 OBS [83]	No significant differences were found	High	0	0	0	-1	0	0	0	0	Moderate	Moderate
	Bacteriuria/Unspecified UTI*	4 SR [1, 51, 63, 64] 6 OBS [66, 68-71, 84]	Significantly increased risk with indwelling catheterization in 3 SR [51, 63, 64] and 2 OBS [68, 69] . Discrepant results in 1 SR [1] . No significant differences were found in 2 OBS [66, 84] . Statistical differences were not reported in 2 OBS [70, 71]	High	0	-1	0	0	0	0	0	0	Moderate	
	Bacteremia	1 OBS [68]	Statistical differences were not reported	Low	0	0	0	-1	0	0	0	0	Very Low	
	Recatheterization*	3 SR [1, 51, 63] 1 RCT [65]	Significantly increased risk with indwelling catheterization in 2 SRs [1, 51] . No significant differences were found in 1 SR [63] . Statistical differences were not reported in the RCT [65]	High	0	0	0	0	0	0	0	0	High	
	Urinary retention	1 SR [64]	No significant differences were found in the SR [64] . Statistical	High	-1	0	0	-1	0	0	0	0	Low	

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
		1 OBS [71]	differences were not reported in the OBS [71] .											
	Hospital length of stay	2 SR [1, 51] 2 OBS [66, 71]	Significantly increased risk with indwelling catheterization in 2 SRs [1, 51] . No significant differences in 1 OBS [66] . Statistical differences were not reported in 1 OBS [71]	High	-1	0	0	-1	0	0	0	0	Low	
	Duration of catheterization*	2 SR [51, 64] 1 OBS [66]	Significantly increased risk with suprapubic catheterization in 1 SR [51] and 1 OBS [66] . Suggestion of increase in 1 SR [64] .	High	0	0	0	-1	0	0	0	0	Moderate	
	Pain/discomfort*	3 SR [51, 63, 64] 1 OBS [66]	Significantly increased risk with indwelling catheterization in all studies	High	0	0	0	0	0	0	0	0	High	
	Patient satisfaction*	1 SR [64] 1 RCT [65]	Suprapubic catheter was shown to be preferred in 1 SR [64] . No significant differences in patient satisfaction outcomes were found in 1 RCT [65]	High	0	-1	0	0	0	0	0	0	Moderate	
	Stricture*	3 OBS [68, 69, 83]	Significantly increased risk with indwelling catheterization in all studies	Low	0	0	0	0	0	+1	0	0	Moderate	
	Dislodgement	1 OBS [68]	Statistical differences were not reported	Low	0	0	0	-1	0	0	0	0	Very Low	
	Calculi	2 OBS [83, 84]	No significant differences were found	Low	-1	0	0	0	0	0	0	0	Very Low	
	Vesicoureteral reflux	1 OBS [83]	No significant differences were found	Low	-1	0	0	0	0	0	0	0	Very Low	
Suprapubic vs. intermittent catheterization	Symptomatic UTI*	1 OBS [83]	No significant differences were found	Low	0	0	0	-1	0	0	0	0	Very Low	Very Low
	Bacteriuria/Unspecified	2 RCT [72,	Significantly increased risk with intermittent catheterization in 1 OBS [74]	High	0	-1	-1	0	0	0	0	0	Low	

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
	UTI*	[73] 2 OBS [74, 84]	and during early follow-up in 1 RCT [73] . No significant differences were found in 1 RCT [72] , 1 OBS [84] and during late follow-up in 1 RCT [73]											
	Duration of catheterization*	2 RCT [72, 73]	No significant differences were found	High	0	0	-1	0	0	0	0	0	Moderate	
	Patient satisfaction*	2 RCT [72, 73]	1 RCT [72] showed mixed results. The other RCT [73] showed significantly improved patient acceptability with intermittent catheterization.	High	0	-1	-2	0	0	0	0	0	Very Low	
	Stricture*	1 OBS [83]	No significant differences were found	Low	-1	0	0	0	0	0	0	0	Very Low	
	Calculi*	2 OBS [83, 84]	Significantly decreased risk of bladder calculi with intermittent catheterization, but no significant differences in upper tract calculi in 1 OBS [83] . No significant differences in upper or lower tract calculi were found in the other OBS [84]	Low	-1	0	0	0	0	0	0	0	Very Low	
	Abnormal upper tract*	1 OBS [83]	Significantly decreased risk with intermittent catheterization	Low	-1	0	0	0	0	0	0	0	Very Low	
	Vesicoureteral reflux*	1 OBS [83]	Significantly decreased risk with intermittent catheterization	Low	-1	0	0	0	0	0	0	0	Very Low	
Clean vs. sterile intermittent catheterization	Symptomatic UTI*	4 RCT [76, 78, 79, 81]	No significant differences were found in 2 RCTs [76, 79] . Statistical differences were not reported in 2 RCTs [78, 81]	High	-1	0	0	0	0	0	0	0	Moderate	Moderate
	Bacteriuria/Unspecified UTI*	1 SR [61] 6 RCT [75-78, 80, 81] 1 OBS [82]	Significantly decreased risk with the sterile method in the OBS [82] . No significant differences were found in 1 SR [61] and 4 RCTs[75, 77, 78, 80] . Statistical differences were not reported in 2 RCTs [76, 81]	High	-1	0	0	0	0	0	0	0	Moderate	
	Time to infection	2 RCT [76, 79]	No significant differences were found	High	-1	0	0	0	0	0	0	0	Moderate	

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
	Nursing time	1 RCT [79]	Significantly decreased with the clean method	High	-1	0	0	-1	0	0	0	0	Low	
	Mortality	1 RCT [81]	Statistical differences were not reported	High	-1	0	0	-1	0	0	0	0	Low	

* These modifiers can impact the GRADE by 1 or 2 points

B. What are the risks and benefits associated with different catheters or collecting systems?

Table 2B

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
Silver-coated catheter vs. control	Symptomatic UTI*	2 OBS [93, 97]	Significantly decreased risk with silver-alloy catheters in 1 OBS [97] . Statistical differences were not reported in 1 OBS [93]	Low	0	0	0	0	0	0	0	0	Low	Low
	Bacteriuria/unspecified UTI*	4 SR [85, 87-89] 1 MA [86] 1 RCT [90]	Significantly decreased risk with silver alloy catheters in 2 SRs [85, 89] , 1 MA [86] and 1 OBS [95] . There was a possible decrease in risk in 1 OBS [98] . 2 SRs found no significant differences with silver-oxide catheters [85, 89] , although there was a significantly decreased risk in women in 1 SR	High	0	0	-1	0	0	0	0	0	Moderate	

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
		7 OBS [91, 92, 94-96, 98, 99]	[85] . 2 SRs that did not pool data found a decreased risk with silver-coated catheters, particularly when compared with latex rather than silicone catheters [87] , or in studies of poorer quality [88] . The effect of silver alloy catheters was more pronounced when compared with latex catheters rather than silicone catheters in1 MA [86] and at <1 week of catheterization than at >1 week in 1 SR [85] . No significant differences were found in 1 RCT [90] and 3 OBS [92, 94, 96] .Statistical differences were not reported in 2 OBS [91, 99] .										
	Time to bacteriuria	1 OBS [94]	No significant differences were found, although there was a suggestion of decrease	Low	0	0	0	-1	0	0	0	0	Very Low	
	Bacteremia	2 OBS [91, 92]	No significant differences were found in 1 OBS [92] . Statistical differences were not reported in the other OBS [91]	Low	0	0	0	-1	0	0	0	0	Very Low	
	Duration of catheterization	4 OBS [34, 93, 94, 99]	Significantly decreased risk with silver-oxide catheters in 1 OBS [34] . No significant differences were found in 1 OBS [94] and statistical differences were not reported in 2 OBS [93, 99]	Low	-1	0	0	0	0	0	0	0	Very Low	
	Antimicrobial resistance*	1 SR [87] 1 OBS [95]	No antimicrobial resistance was found with the use of silver coated catheters	High	-1	0	0	-1	0	0	0	0	Low	
	Urethral discharge*	1 SR [85] 1 OBS [99]	No significant differences were found in the SR [85] . Statistical differences were not reported in the OBS [99]	High	-1	0	0	-1	0	0	0	0	Low	
	Pain/itching/burning*	1 SR [85] 1 OBS [99]	No significant differences were found in the SR [85] . Statistical differences were not reported in the OBS [99]	High	0	0	-1	-1	0	0	0	0	Low	
Antibiotic-coated catheter vs. control	Symptomatic UTI*	1 SR [85]	No significant differences were found	High	-1	0	0	-1	0	0	0	0	Low	Low
	Bacteriuria/unspecified	2 SR [85, 87]	Significantly decreased risk if catheterization < 1 week but not if	High	0	0	-2	0	0	0	0	0	Low	

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
	UTI*	1 OBS [102]	catheterization > 1 week in 1 SR [85] . No significant differences were found in the other SR [87] and the OBS [102]											
	Antimicrobial resistance*	1 SR [87]	No antimicrobial resistance was found	High	0	0	-2	0	0	0	0	0	Low	
Hydrophilic coated catheter vs. control	Symptomatic UTI*	3 RCT [104, 106, 107] 1 OBS [109]	Significantly decreased risk in 1 RCT of long term intermittent catheterization [104] . No significant differences were found in 1 RCT [107] and 1 OBS [109] . Statistical differences were not reported in 1 RCT [106]	High	-1	-1	0	0	0	0	0	0	Low	Very Low
	Bacteriuria/unspecified UTI*	1 SR [85] 4 RCT [104, 106-108] 1 OBS [109]	Significantly decreased risk in 1 RCT [106] . No significant differences were found in 1 SR [85] , 3 RCTs [104, 107, 108] and 1 OBS [109]	High	-1	-1	-1	0	0	0	0	0	Very Low	
	Hematuria*	4 RCT [104-107] 1 OBS [109]	Significantly decreased risk in 2 RCTs [105, 107] . No significant differences were found in 2 RCTs [104, 106] and 1 OBS [109]	High	-1	-1	0	0	0	0	0	0	Low	
	Urethritis	1 OBS [109]	No significant differences were found	Low	0	0	0	-1	0	0	0	0	Very Low	
	Patient satisfaction*	2 RCT [104, 105]	No significant differences were found in 1 RCT [104] . Statistical differences were not reported in 1 RCT [105] . However, there was a suggestion of increased satisfaction in both	High	0	0	0	-1	0	0	0	0	Moderate	
	Pain/discomfort*	2 RCT [105, 106]	Significantly decreased risk in both RCTs	High	0	0	0	-1	0	0	0	0	Moderate	
	Dysuria	1 RCT [105]	No significant differences were found	High	0	0	-1	-1	0	0	0	0	Low	
	Stricture	1 RCT [106]	No significant differences were found	High	0	0	-1	-1	0	0	0	0	Low	
Closed vs. open	Symptomatic UTI*	1 OBS [124]	No significant differences were found	Low	0	0	0	-1	0	0	0	0	Very Low	Very Low

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
drainage system	Bacteriuria*	1 OBS [125]	Significantly decreased risk	Low	-1	0	0	0	0	0	0	0	Very Low	
	Bacteremia*	1 OBS [124]	No significant differences were found	Low	0	0	0	-1	0	0	0	0	Very Low	
	Mortality*	1 OBS [124]	No significant differences were found	Low	0	0	0	-1	0	0	0	0	Very Low	
	Duration of catheterization	1 OBS [124]	No significant differences were found	Low	0	0	0	-1	0	0	0	0	Very Low	
Complex vs. simple drainage system	Bacteriuria*	4 RCT [113, 115, 116, 118] 3 OBS [123, 130, 131]	Significantly decreased risk in 2 RCTs [116, 118] and 1 OBS [131], all of which were published prior to 1990. No significant differences were found in 2 RCTs [113, 115] and 2 OBS [123, 130]	High	0	-1	-1	0	0	0	0	0	Low	Low
	Time to bacteriuria	2 RCT [113, 116] 2 OBS [123, 130]	Significantly decreased risk in 1 RCT [113]. No significant differences were found in 1 RCT [116] and 2 OBS [123, 130]	High	0	-1	-1	0	0	0	0	0	Low	
	Length of ICU stay	1 RCT [113] 1 OBS [130]	Significantly decreased risk in 1 RCT [113]. No significant differences were found in 1 OBS [130]	High	0	-1	-1	0	0	0	0	0	Low	
	Duration of catheterization	2 RCT [113, 115] 3 OBS [123, 130, 131]	Significantly decreased risk in 1 RCT [113]. No significant differences were found in 1 RCT [115] and 3 OBS [123, 130, 131]	High	0	-1	-1	0	0	0	0	0	Low	
	Urethral discharge	1 RCT [118]	No significant differences were found	High	-1	0	0	-1	0	0	0	0	Low	
	Incontinence	1 RCT [118]	No significant differences were found	High	-1	0	0	-1	0	0	0	0	Low	
Pre-connected/Sealed	Symptomatic UTI*	1 RCT [117]	Significantly decreased risk in 1 OBS [129]. No significant differences	High	-1	-1	0	0	0	0	0	0	Low	Low

Comparison	Outcome	Quantity and type of evidence	Findings	Starting grade	Decrease GRADE					Increase GRADE			GRADE of Evidence for Outcome	Overall GRADE of Evidence Base
					Study Quality*	Consistency	Directness*	Precision	Publication Bias	Large Magnitude*	Dose-response	Confounders		
junction catheter vs. control		1 OBS [129]	were found in 1 RCT [117]											
	Bacteriuria*	3 RCT [114, 117, 119]	Significantly decreased in patients not receiving antibiotics in 1 RCT [119]. No significant differences were found in 2 RCTs [114, 117]	High	-1	0	0	0	0	0	0	0	Moderate	
	Mortality	2 RCT [114, 119]	Significantly decreased in patients not receiving antibiotics in 1 RCT [119]. No significant differences were found in 1 RCT [114]	High	-1	0	0	0	0	0	0	0	Moderate	
	Time to symptomatic UTI	1 OBS [129]	Significantly decreased	Low	0	0	0	0	0	0	0	0	Low	
	Duration of catheterization	3 RCT [114, 117, 119]	No significant differences were found	High	-1	0	0	0	0	0	0	0	Moderate	
Catheter valve vs. catheter bag	Bacteriuria/unspecified UTI*	1 SR [112]	No significant differences were found	High	0	0	0	-1	0	0	0	0	Moderate	Moderate
	Pain/bladder spasms*	1 SR [112]	No significant differences were found	High	0	0	0	-1	0	0	0	0	Moderate	
	Incontinence	1 SR [112]	No significant differences were found	High	0	0	0	-1	0	0	0	0	Moderate	
	Patient satisfaction*	1 SR [112]	Significantly increased for catheter valve	High	0	0	0	-1	0	0	0	0	Moderate	

* These modifiers can impact the GRADE by 1 or 2 points

C. What are the risks and benefits associated with different catheter management techniques?

D. What are the risks and benefits associated with different systems changes?

Question 3: What are the best methods to manage catheter-associated complications?

A. What are the best methods to manage an obstructed urinary catheter?

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