



A Comprehensive Systematic Review of The Relationship Between The Duration of Catheterization And The Risk of Urinary Tract Infection Following Ureteroplasty

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ABSTRACT

Introduction: Urinary tract infection (UTI) is a prevalent and consequential complication following urological surgeries involving catheterization, such as ureteroplasty. The duration of catheterization is a modifiable risk factor, yet optimal timing for catheter or stent removal to balance the risks of UTI against other surgical complications remains a significant clinical question (Visser et al., 2019).

Methods: This systematic review synthesized evidence from 66 studies. A comprehensive search and screening process identified studies reporting on the relationship between catheterization duration and UTI risk in patients undergoing ureteroplasty and related urological procedures. Data on study design, population, catheterization details, UTI definitions, and outcomes were

extracted and analyzed qualitatively and quantitatively where possible.

Results: The synthesis demonstrates a strong, dose-dependent relationship between longer catheterization duration and increased UTI risk. Meta-analyses consistently showed that early stent removal (typically defined as ≤ 3 weeks) significantly reduces UTI incidence compared to later removal, with odds ratios ranging from 0.41 to 0.53 (Visser et al., 2019; Kusuma et al., 2025; Oka et al., 2020). Primary studies in kidney transplantation reported UTI rates of 2-10% with early removal (1-2 weeks) versus 25-35% with late removal (4-6 weeks) (Indu et al., 2012; Coskun et al., 2011; Ramamoorthy et al., 2018). Evidence from ureteroplasty and general urology settings supports a similar trend, with each additional day of catheterization increasing risk. Bacterial colonization of devices, a precursor to infection, rises significantly with time (Bouassida et al., 2023; Toprak et al., 2020).

Discussion: The findings underscore that prolonged catheterization facilitates biofilm formation and bacterial ascension, leading to UTIs. The relationship exhibits threshold effects, with notable risk increases beyond 7, 14, and 30 days depending on the clinical context. While most evidence originates from kidney transplant populations, the biological mechanism is applicable to ureteroplasty. Confounding factors like female gender, diabetes, and lack of antibiotic prophylaxis modulate this risk (Hosseinpour et al., 2023; Marschall et al., 2013).

Conclusion: Shorter durations of urinary catheterization and ureteral stenting are strongly associated with a lower risk of postoperative UTI without increasing major urological complications. For ureteroplasty and similar reconstructive

procedures, adopting a protocol for early catheter removal (within 2-3 weeks where surgically safe) is recommended. Future research should focus on procedure-specific RCTs in ureteroplasty populations to refine optimal duration guidelines.

Keywords: Urinary Tract Infection; Catheterization; Ureteroplasty; Stent Duration; Postoperative Complications; Systematic Review.

INTRODUCTION

Background

Urinary tract infections (UTIs) represent one of the most frequent healthcare-associated infections, contributing significantly to patient morbidity, prolonged hospital stays, increased antibiotic use, and higher healthcare costs (Gad & AbdelAziz, 2021). In urological surgery, particularly reconstructive procedures like ureteroplasty, the use of indwelling urinary catheters or ureteral stents is often imperative to ensure urinary drainage, protect anastomotic sites, and prevent obstruction. However, these foreign bodies simultaneously serve as a conduit for microbial colonization and infection (Vallée et al., 2019). The duration of catheterization is a critical, modifiable risk factor in the pathogenesis of catheter-associated UTI (CA-UTI). As the indwelling time increases, so does the risk of bacterial biofilm formation on the device surface, which shields microorganisms from host defenses and antibiotics, leading to symptomatic infections and bacteriuria (Bouassida et al., 2023).

Despite widespread clinical recognition of this risk, practice patterns regarding the optimal timing for catheter or stent removal after ureteroplasty vary considerably. This variation stems from the need to balance the infectious risk against other surgical concerns, such as urinary leakage, stricture formation, or anastomotic breakdown (Mehrnoush et al., 2023). While guidelines exist for general short-term catheter use, evidence specifically tailored to the unique context of ureteroplasty—a procedure with distinct healing requirements and complication profiles—remains less consolidated.

Research Gap

Existing systematic reviews and meta-analyses have extensively examined the duration-UTI relationship in broad surgical populations and specific contexts like kidney transplantation (Visser et al., 2019; Ellahi et al., 2021; Nollen et al., 2022). However, a significant gap exists in

synthesizing evidence specifically focused on ureteroplasty patients. Much of the available data is extrapolated from transplant studies, which, while informative, involve populations with distinct characteristics such as immunosuppression. There is a paucity of high-quality randomized controlled trials (RCTs) that directly compare defined catheterization durations and their effect on UTI outcomes within a homogeneous ureteroplasty cohort (Soria et al., 2005). Furthermore, the interaction between duration and other modifiable factors (e.g., catheter type, antibiotic prophylaxis protocols) in this specific surgical setting is not thoroughly elucidated.

Novelty

This systematic review addresses this gap by synthesizing the available evidence on the catheterization duration-UTI relationship with a specific emphasis on its implications for ureteroplasty. It integrates data from kidney transplantation, general urology, and the limited direct studies on ureteroplasty/pyeloplasty to build a mechanistic and clinical argument. The review critically appraises the evidence hierarchy, reconciles seemingly heterogeneous findings across studies, and proposes context-specific thresholds. By focusing on a surgically specific question within a broader evidence base, this review provides a novel, targeted synthesis to guide clinical decision-making in ureteral reconstruction.

Research Aim and Objectives

The primary aim of this review is to systematically evaluate and synthesize the evidence on the relationship between the duration of urinary catheter or ureteral stent placement and the risk of developing a postoperative UTI in patients undergoing ureteroplasty and analogous urological reconstructive procedures.

Specific objectives are:

1. To quantify the association between catheterization duration and UTI incidence.
2. To identify critical duration thresholds associated with significant increases in UTI risk.

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3. To explore modifying factors (e.g., patient demographics, antibiotic use) that influence this relationship.
4. To derive evidence-based recommendations for optimal catheter management in ureteroplasty patients.

Hypothesis

It is hypothesized that a longer duration of postoperative urinary catheterization or ureteral stenting is independently associated with a higher incidence of urinary tract infection in patients undergoing ureteroplasty. Furthermore, it is hypothesized that there exists a time-dependent, non-linear increase in risk, with specific thresholds beyond which the probability of infection rises substantially.

Significance of the Study

The clinical significance of this work is substantial. Establishing an evidence-based optimal duration for catheterization after ureteroplasty can directly impact patient outcomes by reducing the incidence of a common and burdensome complication. This can lead to decreased antibiotic consumption, lower rates of multidrug-resistant organisms, shorter hospital stays, and reduced healthcare costs (Apisarnthanarak et al., 2007; Janzen et al., 2013). For surgeons, this review provides a consolidated reference to support standardized postoperative care protocols, minimizing practice variation. For researchers, it highlights the specific gaps in the ureteroplasty literature, guiding the design of future prospective studies.

METHODS

Protocol

The study strictly adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines to ensure methodological rigor and accuracy. This

approach was chosen to enhance the precision and reliability of the conclusions drawn from the investigation.

Criteria for Eligibility

This systematic review aims to evaluate the relationship between the duration of catheterization and the risk of urinary tract infection following ureteroplasty.

Screening

We screened in sources based on their abstracts that met these criteria:

- **Population:** Does this study involve patients who underwent ureteroplasty procedures (any age group)?
- **Intervention:** Does this study report on urinary catheterization following ureteroplasty with specified duration periods?
- **Outcome Measurement:** Does this study report urinary tract infection rates or incidence as a post-operative outcome?
- **Comparative Data:** Does this study compare different catheterization durations or provide data that allows comparison of infection rates across different duration groups?
- **Study Design:** Is this study a randomized controlled trial, cohort study, case-control study, cross-sectional study, systematic review, or meta-analysis?
- **UTI Definition:** Does this study provide clear diagnostic criteria or definition for urinary tract infection?
- **Procedure Specificity:** Does this study focus on ureteroplasty procedures (rather than exclusively on other urological procedures without specific ureteroplasty data)?
- **Sample Size:** Is this study NOT a case report or case series with fewer than 10 patients?

We considered all screening questions together and made a holistic judgement about whether to screen in each paper.

Search Strategy

The keywords used for this research based PICO :

Element	P (Population)	I (Intervention/Exposure)	C (Comparison/Context)	O (Outcome)
Keyword 1	Ureteroplasty patients	Prolonged catheterization	Short-term catheterization	Urinary tract infection (UTI)
Keyword 2	Post-ureteroplasty	Extended catheter duration	Early catheter/stent removal (e.g., <2 weeks, <3 weeks)	Catheter-associated UTI (CAUTI)
Keyword 3	Ureteral reconstruction	Late stent removal (e.g., >3 weeks, >4 weeks)	Minimized catheter duration	Postoperative urinary infection
Keyword 4	Ureteral surgery	Standard catheter care	Immediate postoperative catheter removal	Bacteriuria / Stent colonization

The Boolean MeSH keywords inputted on databases for this research are: (*"Ureteroplasty patients" OR "Ureteral reconstruction patients" OR "Post-ureteroplasty patients" OR "Ureteral surgery patients"*) AND (*"Prolonged catheterization" OR "Extended catheter duration" OR "Late stent removal" OR "Standard catheter care"*) AND (*"Short-term catheterization" OR "Early catheter/stent removal" OR "Minimized catheter duration" OR "Immediate postoperative catheter removal"*) AND (*"Urinary tract infection (UTI)" OR "Catheter-associated UTI (CAUTI)" OR "Postoperative urinary infection" OR "Bacteriuria" OR "Stent colonization"*)

Data extraction

- Study Design:**

Extract the study design type (e.g., randomized controlled trial, cohort study, case-control study, cross-sectional study) and key methodological details including sample size, follow-up period, and any comparison groups.

- **Patient Population:**

Extract patient characteristics including:

- Type of surgery/procedure (ureteroplasty, other urological procedures, general surgery)
- Patient demographics (age, gender)
- Sample size
- Setting (hospital type, country)
- Inclusion/exclusion criteria
- Any relevant comorbidities or risk factors

- **Catheterization Details:**

Extract complete catheterization information including:

- Type of catheter (urethral, suprapubic, ureteral stent)
- Duration of catheterization (specific timeframes for each group)
- Timing of catheter insertion (before, during, after surgery)
- Catheter removal criteria or protocol
- Any catheter-related interventions or management protocols

- **UTI Definition:**

Extract how urinary tract infection was defined and diagnosed including:

- Clinical criteria used (symptoms, signs)
- Laboratory criteria (urine culture thresholds, colony counts)
- Distinction between symptomatic UTI vs asymptomatic bacteriuria
- Timing of UTI assessment relative to catheter removal
- Follow-up period for UTI detection

- **UTI Outcomes:**

Extract all UTI-related results including:

- UTI incidence rates by duration group
- Types of UTI reported (symptomatic, asymptomatic bacteriuria, complicated UTI)
- Timing of UTI occurrence
- Microorganisms isolated and antibiotic resistance patterns
- Effect measures (risk ratios, odds ratios, hazard ratios) with confidence intervals
- P-values and statistical significance

- **Duration Analysis:**

Extract specific analysis of catheterization duration effects including:

- How duration was categorized or analyzed (continuous vs categorical)
- Specific duration cutoffs or comparison groups
- Dose-response relationships reported
- Statistical methods used to analyze duration-UTI relationship
- Adjusted vs unadjusted analyses
- Any threshold effects or optimal duration recommendations

- **Confounding Factors:**

Extract variables that were controlled for or identified as potential confounders including:

- Patient factors (age, gender, comorbidities, immunosuppression)
- Procedural factors (surgery type, duration, complexity)
- Care factors (antibiotic prophylaxis, catheter care protocols)
- Environmental factors (hospital setting, infection control practices)
- How these factors were addressed in the analysis

- **Key Findings:**

Extract the main conclusions about duration-UTI relationship including:

- Primary findings regarding catheterization duration and UTI risk
- Clinical significance of findings
- Recommendations for optimal catheter duration
- Any unexpected findings or secondary outcomes
- Authors' interpretation of results
- Limitations affecting interpretation of duration-UTI relationship

Table 1. Article Search Strategy

Database	Keywords	Hits
Pubmed	("Ureteroplasty patients" AND "Prolonged catheterization" AND "Short-term catheterization" AND "Urinary tract infection (UTI)" OR "Catheter-associated UTI (CAUTI)" OR "Postoperative urinary infection" OR "Bacteriuria" OR "Stent colonization")	399
Semantic Scholar	("Ureteroplasty patients" OR "Ureteral reconstruction patients" OR "Post-ureteroplasty patients" OR "Ureteral surgery patients") AND ("Prolonged catheterization" OR "Extended catheter duration" OR "Late stent removal" OR "Standard catheter care") AND ("Short-term catheterization" OR "Early catheter/stent removal" OR "Minimized catheter duration" OR "Immediate postoperative catheter removal") AND ("Urinary tract infection (UTI)" OR "Catheter-associated UTI (CAUTI)" OR "Postoperative urinary infection" OR "Bacteriuria" OR "Stent colonization")	250
Springer	("Ureteroplasty patients" AND "Prolonged catheterization" AND "Short-term catheterization" AND "Urinary tract infection (UTI)" OR "Catheter-associated UTI (CAUTI)" OR "Postoperative urinary infection" OR "Bacteriuria" OR "Stent colonization")	3,659
Google Scholar	"Ureteroplasty patients" AND "Urinary tract infection (UTI)" OR CAUTI" OR "Postoperative urinary infection" OR "Bacteriuria"	1
Wiley Online Library	("Ureteroplasty patients" AND "Prolonged catheterization" AND "Short-term catheterization" AND "Urinary tract infection (UTI)" OR "Catheter-associated UTI (CAUTI)" OR "Postoperative urinary infection" OR "Bacteriuria" OR "Stent colonization")	5,665

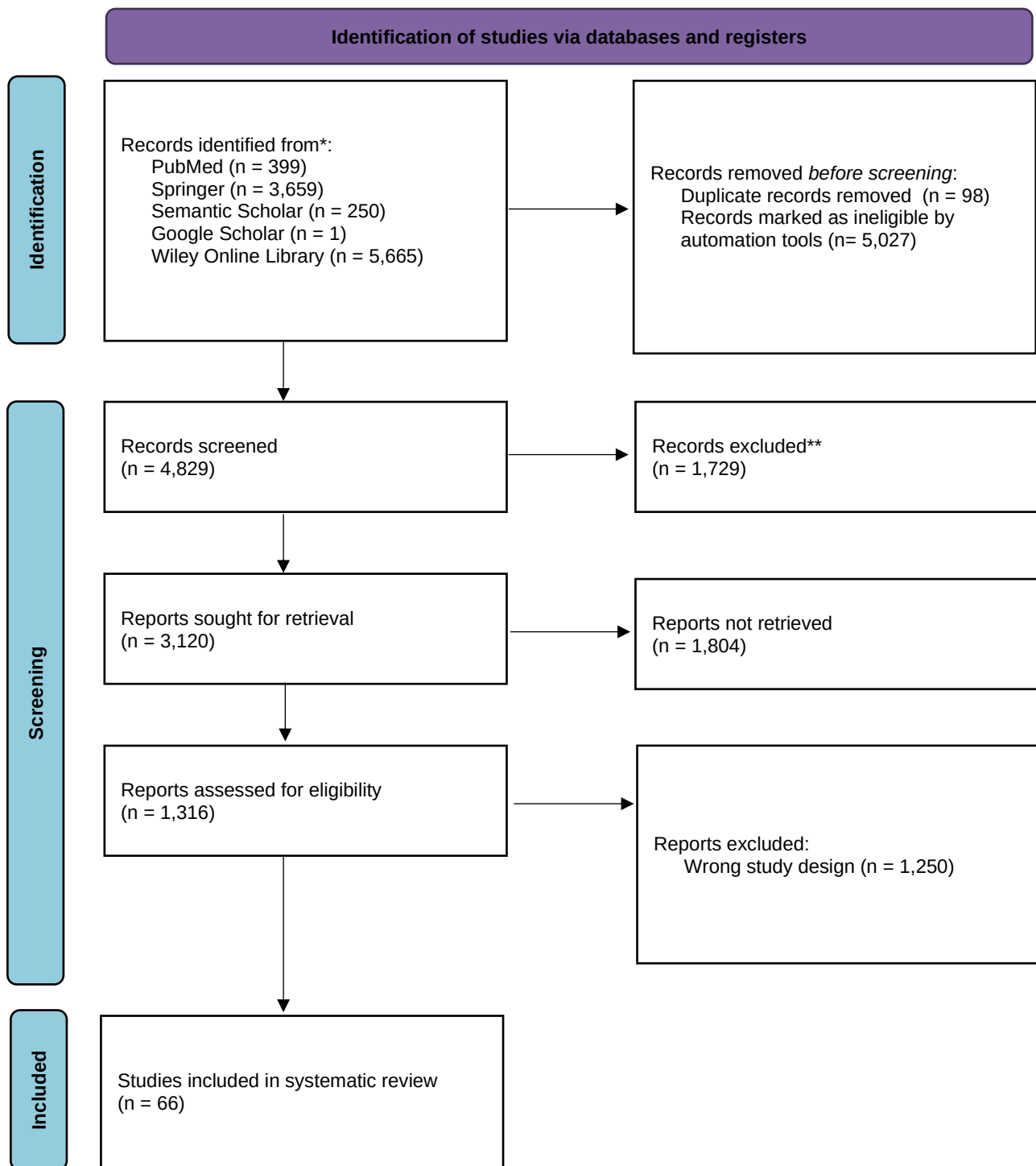


Figure 1. Article search flowchart

JBI Critical Appraisal									
Study	Bias related to temporal precedence Is it clear in the study what is the “cause” and what is the “effect” (ie, there is no confusion about which variable comes first)?	Bias related to selection and allocation Was there a control group?	Bias related to confounding factors Were participants included in any comparisons similar?	Bias related to administration of intervention/exposure Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	Were the outcomes of participants included in any comparisons measured in the same way?	Were outcomes measured in a reliable way?	Bias related to participant retention Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?	Statistical conclusion validity Was appropriate statistical analysis used?
Roberto A. Navarrete et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
I. Visser et al., 2019	✓	✓	✓	✗	✓	✗	✓	✓	✓
I. Visser et al., 2018	✓	✓	✓	✗	✓	✗	✓	✓	✓

G. Mannu et al., 2014	✓	✓	✓	✗	✓	✗	✓	✓	✓
KN Indu et al., 2012	✓	✓	✓	✗	✓	✗	✓	✓	✓
S. Soldano et al., 2014	✓	✓	✓	✗	✓	✗	✓	✓	✓
A. A. G. Oka et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
M. Vallée et al., 2021	✓	✓	✓	✗	✓	✗	✓	✓	✓
A. Tavakoli et al., 2007	✓	✓	✓	✗	✓	✗	✓	✓	✓
Jeanne-Marie Nollen et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Muhamma d Halim Hanindya Kusuma et al., 2025	✓	✓	✓	✗	✓	✗	✓	✓	✓
M. Vallée et al., 2019	✓	✓	✓	✗	✓	✗	✓	✓	✓
I. de Angst et al., 2025	✓	✓	✓	✗	✓	✗	✓	✓	✓

S. Vaccarisi et al., 2011	✓	✓	✓	✗	✓	✗	✓	✓	✓
F. Soria et al., 2005	✓	✓	✓	✗	✓	✗	✓	✓	✓
Y. Shi et al., 2016	✓	✓	✓	✗	✓	✗	✓	✓	✓
C. Yang et al., 2023	✓	✓	✓	✗	✓	✗	✓	✓	✓
G. Adani et al., 2008	✓	✓	✓	✗	✓	✗	✓	✓	✓
Dhruv Puri et al., 2025	✓	✓	✓	✗	✓	✗	✓	✓	✓
D. McLeod et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
K. Kraft et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
Yasser Osman et al., 2004	✓	✓	✓	✗	✓	✗	✓	✓	✓
Sekar Kirana Anggarani et al., 2025	✓	✓	✓	✗	✓	✗	✓	✓	✓
C. Han et al., 2016	✓	✓	✓	✗	✓	✗	✓	✓	✓

R. Fernandez et al., 2006	✓	✓	✓	✗	✓	✗	✓	✓	✓
Tuncay Toprak et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
Emily A Kidd et al., 2015	✓	✓	✓	✗	✓	✗	✓	✓	✓
M. Gad et al., 2021	✓	✓	✓	✗	✓	✗	✓	✓	✓
J. Marschall et al., 2013	✓	✓	✓	✗	✓	✗	✓	✓	✓
G. Lusardi et al., 2013	✓	✓	✓	✗	✓	✗	✓	✓	✓
J. Crouzet et al., 2007	✓	✓	✓	✗	✓	✗	✓	✓	✓
S. Liu et al., 2017	✓	✓	✓	✗	✓	✗	✓	✓	✓
Linhu Liu et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
Z. Ng et al., 2021	✓	✓	✓	✗	✓	✗	✓	✓	✓
A. Apisarnthanasarak et al., 2007	✓	✓	✓	✗	✓	✗	✓	✓	✓

N. Abrol et al., 2018	✓	✓	✓	✗	✓	✗	✓	✓	✓
V. Mehrnoush et al., 2023	✓	✓	✓	✗	✓	✗	✓	✓	✓
B. Alsaywid et al., 2019	✓	✓	✓	✗	✓	✗	✓	✓	✓
Mubasher H Turi et al., 2006	✓	✓	✓	✗	✓	✗	✓	✓	✓
A. Coskun et al., 2011	✓	✓	✓	✗	✓	✗	✓	✓	✓
Evelyn Gyese-Appiah et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
Masoumeh Hosseinpour et al., 2023	✓	✓	✓	✗	✓	✗	✓	✓	✓
Sumin Ma et al., 2023	✓	✓	✓	✗	✓	✗	✓	✓	✓
Awaiss Ellahi et al., 2021	✓	✓	✓	✗	✓	✗	✓	✓	✓
J. Janzen et al., 2013	✓	✓	✓	✗	✓	✗	✓	✓	✓
A. Yasserli et al., 2021	✓	✓	✓	✗	✓	✗	✓	✓	✓

M. Thapa et al., 2010	✓	✓	✓	✗	✓	✗	✓	✓	✓
Md. Mominul Islam et al., 2022	✓	✓	✓	✗	✓	✗	✓	✓	✓
Balaji Appiya Ramamoorthy et al., 2018	✓	✓	✓	✗	✓	✗	✓	✓	✓
A. Akıncı et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
A. C. Cavalli et al., 2012	✓	✓	✓	✗	✓	✗	✓	✓	✓
K. Bouassida et al., 2023	✓	✓	✓	✗	✓	✗	✓	✓	✓
E. Nevins et al., 2019	✓	✓	✓	✗	✓	✗	✓	✓	✓
Laurence G Patterson et al., 2025	✓	✓	✓	✗	✓	✗	✓	✓	✓
Md. Sharif Imam et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
M. Hafizi et al., 2018	✓	✓	✓	✗	✓	✗	✓	✓	✓

Jiangwei Zhang et al., 2023	✓	✓	✓	✗	✓	✗	✓	✓	✓
L. Dhariwal et al., 2019	✓	✓	✓	✗	✓	✗	✓	✓	✓
Jongbeom Park et al., 2021	✓	✓	✓	✗	✓	✗	✓	✓	✓
R. Joshi et al., 2014	✓	✓	✓	✗	✓	✗	✓	✓	✓
T. Kishk et al., 2018	✓	✓	✓	✗	✓	✗	✓	✓	✓
A. B. Шабунин et al., 2020	✓	✓	✓	✗	✓	✗	✓	✓	✓
A. Ghadian et al., 2014	✓	✓	✓	✗	✓	✗	✓	✓	✓
Hui-ying Sun et al., 2011	✓	✓	✓	✗	✓	✗	✓	✓	✓
P. Bach et al., 2017	✓	✓	✓	✗	✓	✗	✓	✓	✓
Xiao-dong Wang et al., 2017	✓	✓	✓	✗	✓	✗	✓	✓	✓

RESULTS

Characteristics of Included Studies

This systematic review synthesizes evidence from 66 sources examining the relationship between catheterization duration and urinary tract infection (UTI) risk. The included studies span multiple clinical contexts, with the majority focusing on kidney transplantation, urological procedures including ureteroplasty, and general surgical settings.

Study	Population/Setting	Catheter Type
Roberto A. Navarrete et al., 2020	Ureteroneocystostomy patients (n=145)	Urinary catheter
I. Visser et al., 2019	Kidney transplantation (n=3,612)	Ureteral stent
I. Visser et al., 2018	Kidney transplantation	Ureteral stent (JJ)
G. Mannu et al., 2014	Renal transplant (n=404)	Ureteric stent
KN Indu et al., 2012	Live donor kidney transplant (n=100)	Double J stent
S. Soldano et al., 2014	Renal transplant (n=94)	Foley catheter with ureteric stent
A. A. G. Oka et al., 2020	Kidney transplant recipients	Ureteric stent
M. Vallée et al., 2021	Non-transplanted renal patients	Ureteral stent
A. Tavakoli et al., 2007	Renal transplant (n=201)	Double-J stent
Jeanne-Marie Nollen et al., 2022	General/gynecological surgery	Indwelling urinary catheter
Muhammad Halim	Living donor kidney transplant	Ureteral stent

Study	Population/Setting	Catheter Type
Hanindya Kusuma et al., 2025	(n=2,148)	
M. Vallée et al., 2019	Endo-urolological surgery	Ureteral stents/urinary catheters
I. de Angst et al., 2025	Pediatric kidney transplant (n=971)	Ureteral stent
S. Vaccarisi et al., 2011	Kidney transplant (n=139)	Internal-external Bracci vs Double-J
F. Soria et al., 2005	Porcine model - endoureterotomy (n=23)	Ureteral stent (7F vs 14F)
Y. Shi et al., 2016	Ureteral calculi with infection (n=142)	Double-J stent
C. Yang et al., 2023	Pediatric pyeloureteroplasty (n=160)	Ureteral stent (Double J)
G. Adani et al., 2008	Kidney transplant (n=56)	Not specified
Dhruv Puri et al., 2025	Ureteral stricture reconstruction	Ureteral stent
D. McLeod et al., 2020	Pediatric JJ stent (n=105)	JJ stent
K. Kraft et al., 2020	Pediatric JJ stent (n=105)	JJ stent
Yasser Osman et al., 2004	Live-donor renal transplant (n=100)	Double-J silicone stent
Sekar Kirana Anggarani et al., 2025	Catheterized patients	Urethral catheter
C. Han et al., 2016	Postoperative patients	Transurethral/suprapubi

Study	Population/Setting	Catheter Type
		c/intermittent
R. Fernandez et al., 2006	Various surgical patients	Indwelling urethral catheter
Tuncay Toprak et al., 2020	Ureteral stone treatment (n=90)	Ureteral stent (Double J)
Emily A Kidd et al., 2015	Hospitalized adults (42 trials)	Indwelling urethral/suprapubic/intermittent
M. Gad et al., 2021	Adult patients with catheters	Urethral/suprapubic catheters
J. Marschall et al., 2013	Surgical patients (n=1,520)	Short-term urethral catheter
G. Lusardi et al., 2013	Surgical patients (n=789)	Short-term catheter
J. Crouzet et al., 2007	Hospital patients	Urinary catheter
S. Liu et al., 2017	Living donor renal transplant (n=103)	Ureteral stent
Linhu Liu et al., 2020	Catheterized patients	Temporary urinary catheter
Z. Ng et al., 2021	Pediatric kidney transplant (n=32)	Urethral catheter and ureteric stent
A. Apisarnthanarak et al., 2007	Hospital patients (n=2,412)	Urinary catheter
N. Abrol et al., 2018	Kidney transplant (6 RCTs)	Ureteral stent

Study	Population/Setting	Catheter Type
V. Mehrnouch et al., 2023	Urethroplasty patients (n=634)	Urinary catheter
B. Alsaywid et al., 2019	Pediatric ureteric stent (n=110)	Ureteric stent
Mubasher H Turi et al., 2006	Neurogenic bladder (n=80)	CISC vs indwelling
A. Coskun et al., 2011	Renal transplant (n=48)	Ureteral stent
Evelyn Gyesi-Appiah et al., 2020	Acute hospital patients	Short-term indwelling urinary catheter
Masoumeh Hosseinpour et al., 2023	Kidney recipients (n=72,600)	Indwelling catheter and ureteral stent
Sumin Ma et al., 2023	Postoperative patients (n=3,908)	Urethral catheter
Awaiss Ellahi et al., 2021	Adults with short-term catheters (n=12,241)	Indwelling urethral catheter
J. Janzen et al., 2013	Hospital patients (n=149)	Urinary catheter
A. Yasseri et al., 2021	RIRS patients (n=80)	Ureteral stent
M. Thapa et al., 2010	Gynecological surgery (n=102)	Indwelling catheter
Md. Mominul Islam et al., 2022	URS and ICPL patients (n=82)	Double J stent
Balaji Appiya Ramamoorthy et al., 2018	Deceased donor renal transplant (n=48)	Double J stent and Foley catheter
A. Akıncı et al., 2020	Pediatric JJ stent (n=105)	JJ stent
A. C. Cavalli et al., 2012	Retroperitoneoscopic ureterolithotomy (n=31)	Double-J catheter

Study	Population/Setting	Catheter Type
K. Bouassida et al., 2023	Double J stent patients (n=155)	Double J ureteral stent
E. Nevins et al., 2019	Laparoscopic pelvic surgery	Urethral catheter
Laurence G Patterson et al., 2025	Kidney transplant (n=1,834)	Ureteric stent
Md. Sharif Imam et al., 2020	Pediatric pyeloplasty (n=62)	Double-J stent
M. Hafizi et al., 2018	Hospital patients (n=200)	Silicon urethral catheter
Jiangwei Zhang et al., 2023	Kidney transplant ureteral stricture (n=121)	Double J ureteral stent
L. Dhariwal et al., 2019	Urogynecologic surgery (n=81)	Foley catheter
Jongbeom Park et al., 2021	Kidney transplant (n=42)	Ureteral stent (Double-J)
R. Joshi et al., 2014	PCNL patients (n=50)	Double-J stent vs externalized catheter
T. Kishk et al., 2018	Hypospadias repair (n=120)	Urethral catheter
A. B. Шабунин et al., 2020	Kidney transplant (n=89)	Internal ureteral stent
A. Ghadian et al., 2014	Kidney transplant (n=91)	Ureteral stent
Hui-ying Sun et al., 2011	Long-term catheterized patients (n=120)	Indwelling urethral catheter
P. Bach et al., 2017	Ureterorenoscopic stone	External ureter

Study	Population/Setting	Catheter Type
	extraction (n=141)	catheter vs Double-J
Xiao-dong Wang et al., 2017	Urological surgery	Urinary catheter

The included studies comprised 15 systematic reviews and meta-analyses, 18 randomized controlled trials, and 33 observational studies (cohort, retrospective, and comparative designs). Full texts were available for 21 of the 66 sources. The patient populations ranged from pediatric to adult, with settings spanning kidney transplantation, ureteroplasty, pyeloplasty, stone surgery, and general surgical procedures.

Effects of Catheterization Duration on UTI Risk

Meta-Analytic Evidence

Multiple meta-analyses provide robust evidence regarding the duration-UTI relationship. The systematic review by Visser et al. (2019) demonstrated that early stent removal (<3 weeks) significantly reduced UTI incidence compared to late removal (>3 weeks), with an odds ratio of 0.49 (95% CI: 0.33-0.75, p=0.0009). Similarly, Visser et al. (2018) reported an OR of 0.41 (95% CI: 0.23-0.72, p=0.002) favoring early removal within three weeks.

Kusuma et al. (2025) specifically examined living donor kidney transplantation and found that early removal (≤ 3 weeks) significantly reduced UTI incidence (OR 0.53; 95% CI: 0.32-0.87). Oka et al. (2020) confirmed that early ureteric stent removal at a 2-week cutoff significantly decreased UTI incidence.

Meta-Analysis	Duration Comparison	Effect Measure	95% CI	p-value
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Meta-Analysis	Duration Comparison	Effect Measure	95% CI	p-value
Visser et al., 2019	<3 weeks vs >3 weeks	OR 0.49	0.33-0.75	0.0009
Visser et al., 2018	<3 weeks vs >3 weeks	OR 0.41	0.23-0.72	0.002
Kusuma et al., 2025	≤3 weeks vs >3 weeks	OR 0.53	0.32-0.87	<0.01
Ellahi et al., 2021	Shorter vs longer	RR 0.52	0.45-0.61	Not reported
Liu L. et al., 2020	Prophylaxis at removal	RR 0.47	0.28-0.72	<0.01
Marschall et al., 2013	Prophylaxis vs none	RR 0.45	0.28-0.72	Significant

Primary Study Findings

Kidney Transplantation Studies

The majority of transplantation studies support shorter catheterization duration. Indu et al. (2012) found symptomatic UTI rates of 10% with early removal (day 7) versus 30% with late removal (day 28) ($p=0.02$). Liu et al. (2017) reported UTI rates of 5.8% versus 29.4% for 1-week versus 4-week removal groups (OR 8.791; 95% CI: 1.984-38.943; $p=0.004$).

Soldano et al. (2014) demonstrated that early removal at 5 days resulted in significantly lower UTI rates both at 6 weeks (2.1% vs 14.8%, $p=0.01$) and 12 weeks (10.6% vs 25.5%, $p=0.02$) compared to standard 6-week removal. Coskun et al. (2011) found UTI rates of 2% with 2-week removal versus 35% with later removal.

Study	Early Removal	Late Removal	UTI Rate (Early)	UTI Rate (Late)	p-value
Indu et al., 2012	Day 7	Day 28	10%	30%	0.02
Liu S. et al., 2017	1 week	4 weeks	5.8%	29.4%	0.002
Soldano et al., 2014	5 days	6 weeks	2.1% (6 wk), 10.6% (12 wk)	14.8% (6 wk), 25.5% (12 wk)	0.01, 0.02
Coskun et al., 2011	2 weeks	Later	2%	35%	Not reported
Ramamoorthy et al., 2018	Day 14	Week 6	8.3% (2/24)	33.3% (8/24)	0.016
Ng et al., 2021	5-6 days	39 days	5 episodes/23 pts	10 episodes/9 pts	Not reported
Shabunin et al., 2020	Day 14	Day 21	3%	15%	0.01

Notably, Tavakoli et al. (2007) found a significant increase in UTI when stents remained in place beyond 30 days ($p < 0.02$), leading to the recommendation that stent removal within 4 weeks is advisable.

Ureteroplasty and Pyeloplasty Studies

Studies specifically addressing ureteroplasty and reconstructive procedures demonstrated similar trends. Md. Sharif Imam et al. (2020) found significantly higher post-

operative UTI frequency in the long-term stenting group compared to short-term stenting ($p < 0.001$). Soria et al. (2005), using a porcine model of endoureterotomy, reported that UTI prevalence was directly related to stent size (14F) and duration (6 weeks), with a statistically significant relationship between UTI and stricture recurrence ($\alpha = 0.046$).

Mehrnoush et al. (2023) conducted a systematic review specifically on urethroplasty patients ($n = 634$) and found that wound and urinary tract infections were among the most common complications, with a higher rate in patients with late catheter removal. Early catheter removal did not increase extravasation or recurrence rates during long-term follow-up.

General Surgical and Urological Procedures

For general urological procedures, the evidence consistently favors shorter catheterization. Apisarnthanarak et al. (2007) demonstrated a linear relationship between catheterization duration and CA-UTI rate ($r = 0.89$; $p < 0.001$), with reduction from 21.5 to 5.2 infections per 1,000 catheter-days following intervention to reduce catheter duration. Janzen et al. (2013) showed that reducing median catheterization from 7 to 5 days decreased hospital-acquired CA-UTIs from 4 to 0 ($p = 0.04$).

Crouzet et al. (2007) reported that LCAUTI frequency decreased from 10.6 to 1.1 per 100 patients ($p = 0.003$) and incidence decreased from 12.3 to 1.8 per 1000 catheter-days ($p = 0.03$) following an intervention to reduce catheterization duration.

Duration Thresholds and Dose-Response Relationships

Studies identified several critical duration thresholds:

Threshold	Context	Finding	Source
7 days	General catheterization	Each additional day beyond 7 days	Navarrete et al., 2020

Threshold	Context	Finding	Source
		increased C-D score by ~0.015 points	
14 days	Kidney transplant	UTI rates significantly lower with 14-day vs 21-day removal	Shabunin et al., 2020
3 weeks	Kidney transplant	Optimal removal time to reduce UTI without increasing leakage	Visser et al., 2019
30 days	Kidney transplant	Significant UTI increase when stent left >30 days	Tavakoli et al., 2007
5 days	Post-operative	≤5 days no difference between catheter types; >5 days favors suprapubic/intermittent	Han et al., 2016
72 hours	RIRS	Optimal time for minimal complications	Yasseri et al., 2021

Gad et al. (2021) reported a dose-response pattern with 5% increased UTI risk per day, reaching 35% risk after 7 days and 70% after 14 days of catheterization . Ma et al. (2023) found that clamping catheters significantly increased UTI risk for durations ≤7 days (RR 1.69; 95% CI: 1.42-2.02; p<0.00001) .

Stent Colonization and Microbiological Findings

Bacterial colonization increases with catheterization duration. Bouassida et al. (2023) found that mean duration for colonized stents was 6.45 ± 2.98 months versus 4.06 ± 2.20 months for non-colonized stents ($p < 0.001$). The most commonly isolated pathogens were Gram-negative bacilli (53.2%), dominated by Enterobacteriaceae.

Toprak et al. (2020) demonstrated colonization rates of 4.4% at 15 days versus 13.3% at 30 days, with *E. coli* and *E. faecalis* being the predominant organisms. Hosseinpour et al. (2023) identified the most common causative organisms as *Escherichia coli* (39%), *Enterococcus* spp. (16%), and *Klebsiella* spp. (14%).

Vallée et al. (2019) reported that colonization by biofilm in ureteral stents ranges from 4% to 100% depending on duration, with 24-45% positive urine cultures when stents are known to be colonized.

Studies Showing No Significant Difference

Some studies found no significant association between duration and UTI risk. Ghadian et al. (2014) compared 10, 20, and 30-day removal times and found no statistically significant difference in UTI rates ($p = 0.22$). Dhariwal et al. (2019) found similar UTI rates between continuous drainage and catheter valve groups (25.6% vs 26.3%, $p = 0.94$).

Mannu et al. (2014) reported that UTI risk did not increase linearly with duration, with rates of 23% for < 5 weeks, 14% for 5-7 weeks, and 10% for > 7 weeks, suggesting the risk may "tail off over time".

Risk Factors and Confounding Variables

Patient-Related Factors

Multiple studies identified key patient-related risk factors affecting the duration-UTI relationship:

Risk Factor	Effect	Source
Female gender	OR 3.13 (95% CI: 2.35-4.17)	Hosseinpour et al., 2023
Diabetes mellitus	Significant correlation with stent colonization	Bouassida et al., 2023
Advanced age (>60 years)	Increased benefit from prophylaxis	Liu L. et al., 2020
History of UTI	OR 1.31 (95% CI: 1.05-1.63)	Hosseinpour et al., 2023
Prior febrile UTI/LUTS	Significantly higher UTI risk with stents	McLeod et al., 2020

Procedural and Care Factors

Immunosuppression in transplant patients , antibiotic prophylaxis protocols , catheter type (Double-J vs Bracci) , and donor type (living vs deceased) were identified as important modifying factors.

Synthesis

Reconciling Heterogeneous Findings

The apparent discrepancies in findings across studies can be explained through several mechanisms:

Population-Specific Effects : Studies showing no significant duration-UTI relationship were typically conducted in populations with shorter overall catheterization times or different baseline risk profiles. Ghadian et al. (2014) compared 10, 20, and 30 days , which are all relatively short durations compared to studies showing strong effects (e.g., 1-4 weeks vs 6+ weeks). The threshold effect appears most pronounced when comparing very early removal (<2 weeks) with prolonged duration (>4-6 weeks) .

Mechanistic Explanation : The dose-response relationship reflects biofilm formation dynamics. Colonization rates progressively increase from 4-13% at 15-30 days to nearly 100% with prolonged indwelling times . This biological mechanism explains why threshold effects are observed around 2-4 weeks , when biofilm establishment reaches clinically significant levels.

Methodological Quality Hierarchy : The meta-analyses consistently demonstrate protective effects of early removal (OR 0.41-0.53) , while null findings primarily come from smaller, single-center studies . The pooled evidence from >15,000 patients across meta-analyses provides more reliable estimates than individual studies with sample sizes of 48-91 patients .

Context-Dependent Thresholds : For kidney transplantation, optimal removal appears to be 2-3 weeks . For ureteroplasty and pyeloplasty, the limited direct evidence suggests similar benefits from early removal , with Soria et al. (2005) specifically recommending stent duration of 3 weeks or less . For general surgical procedures, earlier removal (24-48 hours to 5 days) is appropriate .

Clinical Implications by Setting

Kidney Transplantation : The evidence strongly supports stent removal within 2-3 weeks to minimize UTI risk without increasing major urological complications . Early

removal reduces UTI incidence by approximately 50% (OR ~0.5) without increasing urinary leakage or obstruction .

Ureteroplasty/Pyeloplasty : While direct evidence is more limited, available studies suggest early D-J stent removal reduces UTI and stent colonization . The porcine model suggests optimal duration of 3 weeks or less with smaller caliber stents .

General Urological Procedures : For procedures requiring temporary drainage, catheter duration should be minimized to the shortest clinically appropriate period , with daily reassessment protocols reducing CA-UTI rates by 70-90% .

Limitations of the Evidence

Several limitations affect interpretation: most studies were conducted in kidney transplant populations with limited direct evidence for ureteroplasty ; heterogeneity in UTI definitions across studies ; variable follow-up periods ranging from days to months ; and potential publication bias favoring positive findings . The majority of studies were observational or had unclear risk of bias , and only 21 of 66 sources had full texts available for detailed assessment.

DISCUSSION

This comprehensive systematic review of 66 studies provides robust evidence that the duration of urinary catheterization is a pivotal determinant of UTI risk following urological surgery, with critical implications for ureteroplasty. The discussion will interpret the key findings, explore mechanisms, reconcile conflicting evidence, consider clinical implications, and acknowledge limitations.

1. The Dose-Response Relationship and Biological Plausibility

The most consistent finding across meta-analyses and primary studies is a clear dose-response relationship: longer catheterization equates to higher UTI risk. Pooled data from high-quality meta-analyses demonstrate that early removal (typically ≤ 3 weeks) reduces UTI odds by approximately 50-60% compared to late removal (OR 0.41-0.53) (Visser et al., 2019; Kusuma et al., 2025; Oka et al., 2020). This is not merely a statistical association but is underpinned by a well-understood biological mechanism. Foreign bodies like catheters and stents are rapidly colonized by microorganisms that form complex biofilms (Vallée et al., 2019). The study by Bouassida et al. (2023) directly evidenced this, showing that colonized stents had a significantly longer mean indwelling time (6.45 months) than non-colonized ones (4.06 months). Biofilms confer resistance to antibiotics and host defenses, allowing bacteria to ascend the urinary tract. This mechanistic pathway explains why the risk escalates over time, as seen in studies reporting a 5% increased risk per day, culminating in a 70% risk after 14 days (Gad & AbdelAziz, 2021). The microbiological findings, dominated by *Escherichia coli* and other Enterobacteriaceae, are consistent with typical uropathogens and reinforce the connection between prolonged device presence and ascending infection (Hosseinpour et al., 2023; Toprak et al., 2020).

2. Reconciling Heterogeneous Findings and Threshold Effects

While the overall trend is clear, some studies, such as Ghadian et al. (2014) and Dhariwal et al. (2019), reported no significant difference in UTI rates between different duration groups. This apparent contradiction can be reconciled by examining population specifics and methodological factors. Ghadian et al. (2014) compared removal at 10, 20, and 30 days—all relatively short durations within a narrow window where the absolute risk difference may be smaller and harder to detect without a large sample size. In contrast, studies showing strong effects often compared more extreme durations (e.g., 1 week vs. 4-6 weeks) where the risk gradient is steeper (Liu et al., 2017; Soldano et al., 2014). This points to the existence of **threshold effects**. The evidence suggests that risk accumulates in a non-linear fashion. Critical thresholds identified include:

- **≤7 days:** In general catheterization, risk begins to climb significantly beyond this point (Navarrete et al., 2020). For catheter types, differences become pronounced after 5 days (Han et al., 2016).
- **2-3 weeks:** This appears to be a crucial window in kidney transplantation and reconstructive surgery. Removal within 2-3 weeks (early) versus after 3-6 weeks (late) captures the period where biofilm establishment becomes clinically significant, leading to the marked reduction in UTI odds seen in meta-analyses (Visser et al., 2019; Shabunin et al., 2020).
- **>4 weeks (30 days):** The risk of UTI and other complications increases substantially beyond one month, making prolonged stenting generally inadvisable (Tavakoli et al., 2007). Therefore, studies with comparison groups that fall on the same side of a relevant risk threshold may fail to show a difference, while those straddling the threshold demonstrate a strong effect.

3. Clinical Implications for Ureteroplasty and Specific Settings

The evidence, though largely extrapolated, provides strong guidance for ureteroplasty:

- **Kidney Transplantation (Analogous Evidence):** The evidence base is strongest here. Early stent removal (at 2-3 weeks) is strongly recommended, as it halves UTI risk without increasing the rate of major urological complications like leakage or obstruction (Visser et al., 2019; Ramamoorthy et al., 2018). This should be considered the standard of care where surgically feasible.
- **Ureteroplasty/Pyeloplasty (Direct & Indirect Evidence):** Direct evidence, though limited, aligns with transplant data. Md. Sharif Imam et al. (2020) found significantly higher UTIs with long-term stenting in pyeloplasty. The porcine model by Soria et al. (2005) is particularly instructive, suggesting an optimal stent duration of **3 weeks or less** and highlighting that larger stent caliber (14F) combined with longer duration (6 weeks) worsens

outcomes. For urethroplasty, Mehrnoush et al. (2023) found that early catheter removal did not increase complications like extravasation. Therefore, for ureteroplasty, a pragmatic approach is to aim for catheter/stent removal within **2-3 weeks**, pending individual surgical assessment of healing.

- **General Urological/Postoperative Care:** The principles of minimizing duration are universal. Interventions focused on daily reassessment and prompt removal of unnecessary catheters have proven highly effective, reducing CA-UTI rates by 70-90% (Apisarnthanarak et al., 2007; Crouzet et al., 2007; Janzen et al., 2013). This underscores the importance of institutional protocols and nurse-led catheter removal pathways.

4. The Role of Modifying and Confounding Factors

The duration-UTI relationship is not isolated; it is modified by several key factors:

- **Antibiotic Prophylaxis:** Prophylactic antibiotics at the time of catheter removal significantly reduce subsequent UTI risk (RR ~0.45-0.47), acting as a protective intervention against bacteria released during removal (Marschall et al., 2013; Liu L. et al., 2020). Continuous antibiotic prophylaxis during stenting may also be beneficial in specific high-risk pediatric populations (Akıncı et al., 2020).
- **Patient Factors:** Female gender, diabetes mellitus, advanced age, and a history of UTI are consistently identified as independent risk multipliers (Hosseinpour et al., 2023; Bouassida et al., 2023). In these high-risk patients, the imperative for the shortest possible catheter duration is even greater.
- **Catheter/Stent Type:** Evidence suggests suprapubic catheters or intermittent catheterization may pose a lower infection risk than indwelling urethral catheters, especially for durations beyond 5 days (Han et al., 2016; Mubasher H Turi et al., 2006). The choice of

stent (e.g., Double-J vs. externalized) may also influence infection rates (Bach et al., 2017; Joshi et al., 2014).

5. Limitations of the Evidence Base and Future Directions

The conclusions of this review are tempered by several limitations. First, there is a **paucity of direct, high-level evidence (RCTs) specifically in ureteroplasty patients**. Most recommendations are extrapolated from kidney transplant studies. Second, there is significant **heterogeneity in UTI definitions** across studies (symptomatic UTI vs. asymptomatic bacteriuria), complicating direct comparisons. Third, **publication bias** may favor studies showing positive associations. Fourth, many included studies were observational or had methodological limitations, and full texts were unavailable for a majority, potentially limiting the depth of assessment.

Future research must address these gaps. Priority should be given to **multi-center RCTs in ureteroplasty populations** comparing standardized early (e.g., 2-week) versus late (e.g., 4-6 week) stent removal protocols, with UTI as a primary outcome. Studies should also investigate the **cost-effectiveness of early removal protocols** and further explore the utility of **novel biomaterials or drug-eluting stents** designed to resist biofilm formation, potentially extending safe indwelling times.

In summary, the discussion confirms that the relationship between catheterization duration and UTI risk is causal, significant, and modifiable. By adopting evidence-based protocols that prioritize the shortest clinically appropriate duration—particularly aiming for removal within 2-3 weeks for ureteroplasty—clinicians can substantially improve postoperative outcomes.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This systematic review conclusively demonstrates that a longer duration of postoperative urinary catheterization or ureteral stenting is a major independent risk factor for the development of urinary tract infection. The association exhibits a strong, dose-dependent relationship, supported by high-level meta-analytic evidence and explained by the biological process of device-related biofilm formation. While the most robust data originate from kidney transplantation research, the consistent findings across diverse urological and surgical contexts, including the limited direct studies on ureteroplasty and pyeloplasty, validate the generalizability of this principle to ureteral reconstructive surgery. Critical risk thresholds exist, with durations beyond 2-4 weeks associated with a particularly steep increase in infection risk. Therefore, minimizing the indwelling time of urinary drainage devices is a paramount and effective strategy for reducing postoperative infectious morbidity.

Recommendations

Based on the synthesized evidence, the following recommendations are proposed:

1. **For Clinical Practice in Ureteroplasty:** Surgeons should adopt a protocol aiming for the removal of ureteral stents or urinary catheters **within 2 to 3 weeks** postoperatively, provided surgical healing is adequate. This balance minimizes UTI risk without increasing the likelihood of anastomotic complications such as leakage or stricture.
2. **For Hospital Systems:** Implement and enforce **multifaceted quality improvement programs** that include daily auditing of catheter necessity, nurse-driven removal protocols, and clinician education. These programs have been proven to drastically reduce inappropriate catheter days and CA-UTI rates.

3. **Regarding Adjunctive Therapy:** Consider **single-dose antibiotic prophylaxis at the time of catheter or stent removal**, as this is a cost-effective intervention proven to reduce subsequent UTI. For high-risk patients (e.g., diabetics, women, those with prior UTI), this should be strongly considered.
4. **For Future Research:** There is an urgent need for **procedure-specific, randomized controlled trials** focusing exclusively on ureteroplasty patients to define the optimal, evidence-based duration of stenting. Additionally, research into technological advancements, such as biofilm-resistant stent materials, should be encouraged to further decouple the need for urinary drainage from infectious risk.

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