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Short Article

The Impact of Nephrostomy on Urinary Tract Infections – A Literature Review

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Abstract

Background: Percutaneous nephrostomy (PCN) is a well-established minimally invasive procedure utilized for the decompression of the renal collecting system, primarily in the treatment of urinary tract obstruction. Despite its therapeutic benefits, the introduction of an external drainage system creates a direct pathway for microbial invasion, leading to a heightened risk of urinary tract infections (UTIs), particularly catheter-associated urinary tract infections (CAUTIs).

Aim: This literature review aims to provide a comprehensive analysis of the available evidence regarding the incidence, pathophysiological mechanisms, risk factors, microbiological profiles, clinical management, and prevention strategies of urinary tract infections associated with percutaneous nephrostomy.

Material and Methods: A systematic literature review was conducted using PubMed, Scopus, Web of Science, and Google Scholar databases for studies published between 2000 and 2025. Inclusion criteria encompassed original research articles, clinical guidelines, and systematic reviews focusing on adult patients undergoing nephrostomy. Data synthesis was narrative with a focus on epidemiology, mechanisms, and prevention strategies.

Results: The incidence of CAUTIs among nephrostomy patients varies significantly, ranging from 8% to 40%, influenced by factors such as catheter dwell time, patient comorbidities, and catheter care protocols. Key risk factors identified include prolonged catheterization, biofilm formation on catheter surfaces, breaches in aseptic technique, and host immunosuppression. The predominant causative organisms are Gram-negative bacilli, notably *Escherichia coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*, with increasing concern over multidrug-resistant strains. Effective prevention hinges on meticulous catheter care, adherence to aseptic techniques, and prudent antibiotic stewardship.

Conclusions: Percutaneous nephrostomy significantly elevates the risk of urinary tract infections due to the invasive nature of the procedure and biofilm-mediated colonization. Comprehensive prevention strategies, rigorous clinical protocols, and continuous surveillance are paramount to reducing CAUTI incidence in nephrostomy patients.

Keywords: nephrostomy, urinary tract infection, biofilm, catheter-associated infection, prophylaxis, antimicrobial resistance

1. Introduction

Catheter-associated urinary tract infections (CAUTIs) are the most common type of healthcare-associated infections (HAIs), accounting for nearly 40% of all nosocomial infections globally [1]. The widespread use of indwelling urinary catheters in various clinical settings, including acute care, long-term care, and outpatient urology, has led to an increase in iatrogenic urinary tract infections, which contribute to significant morbidity, healthcare costs, and antibiotic consumption.

Percutaneous nephrostomy (PCN), introduced in the 1950s by Goodwin et al. [2], revolutionized the management of obstructive uropathy and remains a cornerstone in decompression of the renal collecting system in both benign and malignant conditions. However, this minimally invasive technique carries a considerable risk of infection due to the creation of a direct tract between the renal pelvis and external environment.

Numerous studies have highlighted the economic burden of CAUTIs in patients with nephrostomy, estimating that hospital stays may be prolonged by an average of 5 to 7 days, with increased use of broad-spectrum antibiotics and elevated rates of hospital readmission [3]. These infections also contribute to the rise of multidrug-resistant (MDR) organisms, necessitating urgent action in terms of infection control and antimicrobial stewardship.

Given the increasing use of nephrostomy in oncological and nephrological care, a systematic understanding of the infection risk profile is essential for clinicians to improve outcomes and prevent complications.

Research Objective

To analyze and synthesize current scientific evidence regarding the relationship between percutaneous nephrostomy and the incidence, mechanisms, risk factors, and preventive measures of urinary tract infections.

Research Problems

- What is the documented incidence of CAUTIs in patients with nephrostomy?
- What are the primary pathophysiological mechanisms leading to infection?
- Which risk factors most significantly influence infection rates?
- What preventive strategies are supported by current evidence?

Research Hypotheses

- Percutaneous nephrostomy is associated with an increased risk of urinary tract infection due to direct access for microorganisms and biofilm formation.
- Implementation of evidence-based catheter care protocols reduces the incidence of nephrostomy-related CAUTIs.

2. Research Materials and Methods

2.1. Participants

This literature review focused on studies involving adult patients (aged 18 years and older) who underwent percutaneous nephrostomy for various urological conditions. The populations included in the selected studies represented diverse demographics and clinical backgrounds, ensuring comprehensive data coverage.

2.2. Procedure / Literature Selection

A structured search strategy was applied across major medical databases (PubMed, Scopus, Web of Science, Google Scholar) using a combination of keywords and Medical Subject Headings (MeSH) terms: “nephrostomy,” “urinary tract infection,” “CAUTI,” “biofilm,” “catheter-related infection,” and “prophylaxis.” The search was limited to articles published between 2000 and 2025, written in English or Polish.

Selection criteria:

Inclusion: Original research articles, clinical guidelines, consensus statements, systematic reviews, and meta-analyses focused on nephrostomy and UTIs in adults.

Exclusion: Case reports, conference abstracts, studies involving pediatric populations, non-human research.

A total of 67 articles were initially identified; after screening for relevance and duplication, 35 studies met the inclusion criteria for detailed review.

3. Research Results

3.1. Epidemiology

Multiple studies report a broad range of infection rates associated with percutaneous nephrostomy, reflecting differences in study populations, procedural techniques, and infection definitions. Reported CAUTI rates range from 8% to 40% [1,3,4]. The European Association of Urology (EAU) highlights the significant infection risk, particularly in long-term catheterizations exceeding 7 days [2].

Study	Year	Design	Infection Rate	Key Findings
Stamatakis et al.	2013	Review	8–40%	CAUTI risk increases with catheter duration
Bonkat et al.	2019	Guidelines	~25%	Biofilm is a key infection factor
Grabe et al.	2022	Guidelines	Variable	Emphasis on preventive care protocols

3.2. Mechanisms of Infection

Biofilm Formation

Biofilms are structured microbial communities embedded in an extracellular matrix that adheres to catheter surfaces. This matrix protects pathogens from both host immune responses and antibiotics, making infections difficult to eradicate once established [5]. Common organisms such as *E. coli*, *K. pneumoniae*, and *P. aeruginosa* exhibit increased virulence in biofilm form. Biofilm formation may occur within 24–48 hours after catheter placement, particularly in the absence of proper sterile technique [6].

Recent evidence also indicates that the material composition of the nephrostomy tube plays a pivotal role in biofilm susceptibility. Silicone-based catheters, for example, may exhibit reduced bacterial adherence compared to latex or polyurethane variants [7].

Ascending Infection

The skin-catheter interface serves as a portal for ascending infection, especially in patients with compromised skin integrity, excessive moisture, or suboptimal dressing techniques. Pathogens

from the skin microbiota may travel along the catheter tract, particularly under conditions that favor microbial motility such as poor fixation or backflow from drainage systems [8].

Host Factors

Individual patient susceptibility is also a key contributor. Immunocompromised individuals, including those undergoing chemotherapy, chronic corticosteroid use, or with diabetes mellitus, are at **significantly higher risk**. Hypoalbuminemia, anemia, and leukopenia have been correlated with a higher incidence of catheter-associated infections, as they impair host defense mechanisms [9].

Duration of Catheterization

The risk of infection correlates directly with catheter dwell time. Prolonged catheter use beyond 7–14 days significantly elevates the risk of colonization and infection [7].

3.3. Risk Factors

Inadequate aseptic technique during insertion and care

Prolonged catheter indwelling time

Immunosuppression (e.g., chemotherapy, transplant recipients)

Presence of comorbid conditions (e.g., diabetes mellitus)

Catheter material and design influencing biofilm formation

4. Discussion

This review highlights the complex and multifactorial etiology of nephrostomy-related CAUTIs. A central theme emerging from the literature is the importance of biofilm-mediated infection, which presents a formidable barrier to successful treatment. Studies have shown that traditional

culture techniques may underestimate bacterial colonization within biofilms, necessitating the use of advanced molecular diagnostics in future research [10].

Catheter replacement strategies vary considerably across institutions. Some centers advocate routine replacement every 6–8 weeks, while others opt for replacements only when clinical symptoms of infection arise. A randomized controlled trial by Ghosh et al. (2021) demonstrated that scheduled catheter changes were associated with a 35% reduction in infection rates compared to symptom-based replacement [11].

Another emerging concept is the use of antibiotic-impregnated catheters, such as those coated with gentamicin or silver alloys. Though promising, these technologies remain cost-prohibitive in many settings and require further validation in large-scale trials [12].

Multidrug-resistant organisms (MDROs) such as extended-spectrum beta-lactamase (ESBL)-producing *E. coli* and carbapenem-resistant *P. aeruginosa* are increasingly isolated from nephrostomy-related infections, especially in long-term catheter users and hospitalized patients. The use of broad-spectrum empiric antibiotics, while often necessary, contributes to resistance development and must be balanced with antimicrobial stewardship principles [13].

Implementation of bundled care protocols, including checklists for insertion and maintenance, has demonstrated success in reducing CAUTI rates in nephrostomy patients. Staff education, patient hygiene training, and regular auditing are integral components of these programs.

5. Conclusion

Percutaneous nephrostomy is an indispensable procedure in modern urology, providing critical relief in cases of obstructive uropathy and impaired urinary drainage. However, its use is intrinsically linked to a heightened risk of catheter-associated urinary tract infections.

The evidence consistently supports the implementation of comprehensive and individualized infection prevention strategies. These include:

rigorous aseptic techniques during insertion and care,
scheduled catheter replacements (every 6–8 weeks),
patient education regarding hygiene and self-monitoring,

and the consideration of innovative antimicrobial materials.

Further research is needed to develop standardized risk assessment tools, explore new antimicrobial technologies, and establish consensus on the role of prophylactic antibiotics. Ultimately, reducing nephrostomy-related infections will improve patient outcomes, reduce healthcare costs, and lower the burden of antimicrobial resistance in hospital settings.

Disclosure

Author Contributions:

Conceptualization: Mikołaj Jankowski;

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All authors have read and agreed with the published version of the manuscript.

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