REVIEW ARTICLE

CATHETER-ASSOCIATED URINARY TRACT INFECTIONS AMONG INTENSIVE CARE PATIENTS

Odcewnikowe zakażenia układu moczowego u pacjentów oddziału intensywnej terapii

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Abstract

Catheter-associated urinary tract infections are a major healthcare concern, particularly in hospitals and intensive care units (ICUs), despite significant educational and preventive efforts. They remain a significant concern in intensive care units settings due to factors such as prolonged catheterization, compromised immunity, and underlying medical conditions. Symptoms of catheter-associated urinary tract infections in intensive care unit patients can vary and may include fever, dysuria, haematuria and lower abdominal discomfort. *Escherichia coli*, *Klebsiella pneumoniae*, and *Candida albicans* are the primary pathogens responsible for catheter-associated urinary tract infections. Catheterized intensive care unit patients are at increased risk of developing catheter-associated urinary tract infections, which contribute to higher morbidity, mortality, and extended hospital stays. Early diagnosis and appropriate treatment are crucial to prevent complications associated with untreated urinary tract infections.

Streszczenie

Odcewnikowe zakażenia układu moczowego stanowią istotny problem zdrowotny, szczególnie w szpitalach i na oddziałach intensywnej terapii. Pomimo wdrażania działań profilaktycznych i edukacyjnych, ich częstość pozostaje wysoka, co wiąże się m.in. z długotrwałym cewnikowaniem, osłabieniem układu odpornościowego oraz współistniejącymi chorobami. Objawy odcewnikowych zakażeń układu moczowego mogą być zróżnicowane i obejmować gorączkę, dyzurię, krwiomocz oraz dyskomfort czy ucisk w podbrzuszu. Do głównych patogenów odpowiedzialnych za te zakażenia należą *Escherichia coli*, *Klebsiella pneumoniae* oraz *Candida albicans*. Pacjenci cewnikowani na oddziałach intensywnej terapii są obarczeni zwiększonym ryzykiem rozwoju tych zakażeń, co prowadzi do wyższej zachorowalności, śmiertelności oraz wydłużonego czasu hospitalizacji. Wczesna diagnostyka i odpowiednie leczenie mają kluczowe znaczenie w zapobieganiu powikłaniom związanym z nieleczonymi zakażeniami układu moczowego.

Keywords: intensive care unit; uropathogens; catheter-associated urinary tract infection; urinary catheter

Słowa kluczowe: oddział intensywnej terapii; uropatogeny; odcewnikowe zakażenie układu moczowego; cewnik moczowy

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Introduction

Catheter-associated urinary tract infections (CAUTIs) represent the most commonly reported nosocomial infections among intensive care unit patients. They typically develop as a consequence of indwelling urinary catheters, which play an instrumental role in monitoring patients' fluid balance [1]. It is estimated that these infections account for approximately 9% of all hospital-acquired infections, impacting an estimated 150 million individuals annually worldwide [2, 3]. According to the latest report from the European Centre for Disease Prevention and Control (ECDC), urinary tract infection (UTI) developed in 2% of patients remaining in the Intensive Care Unit (ICU) for more than 48 hours. A noteworthy finding is that 98% of these infections were associated with urinary catheters, underscoring their pivotal role in the occurrence of UTIs in intensive care settings [4]. Healthcare-associated infections (HAIs), including CAUTIs, are more prevalent in ICU patients compared to other wards, which is due to various factors, such as prolonged catheterization, diabetes, frailty, increased age, malnutrition and antimicrobial therapy [5]. The risk of infection increases with the duration of ICU stay [1]. A study conducted in the ICU at one of the Medical University Teaching Hospital (Poland) demonstrated a strong correlation between hospital-acquired infections and prolonged length of stay (LOS). The findings indicated that patients who developed at least one hospital-acquired infection had a median LOS three times longer compared to those who did not acquire any infections. Furthermore, the impact of multiple infections was found to be even more pronounced, with patients who experienced more than one infection exhibiting a sixfold increase in their median ICU stay. These results underscore the considerable impact of nosocomial infections on critically ill patients, highlighting the need for rigorous infection prevention and control measures to mitigate their effects on patient outcomes and healthcare resource utilisation [6].

This review focuses on the causes, most common pathogens, symptoms, risk factors, diagnostic approaches and current treatment options for ICU patients with CAUTIs.

Definition

Catheter-associated urinary tract infection is defined as a UTI occurring in a patient with an indwelling urinary catheter that has been in place for at least 48 hours prior to the onset of symptoms, with no other identifiable cause of infection [7, 8].

The classification of UTIs is refined based on their anatomical location. Lower UTIs, commonly known as cystitis, primarily affect the bladder and are characterised by symptoms such as frequent urination, painful urination (dysuria), and lower abdominal discomfort, which are seldom expressed in the ICU population due to the specific characteristics of these patients stemming from many factors, such as limited ability to communicate as a result of critical illness. Upper UTIs, medically termed pyelonephritis, involve the kidneys and often present with more severe symptoms, including fever, flank pain, and systemic signs of infection. Accurate diagnosis, effective treatment and prevention of recurrent infections depend on recognising this distinction [9].

Pathogens

UTIs can be caused by a variety of microorganisms, including Gram-negative and Gram-positive bacteria, as well as certain fungal species. Their development is typically associated with the formation of biofilms on the internal (intraluminal) or external (extraluminal) surfaces of urinary catheters, creating an environment that promotes bacterial adhesion and proliferation [7, 9]. The primary uropathogens responsible for these infections often originate from faecal contamination or skin-residing populations, which are part of the patient's natural or transient microflora. These microorganisms colonize the periurethral region and, over time, can ascend into the urinary tract, giving rise to infection. According to scientific evidence, *Escherichia coli* and *Klebsiella pneumoniae* were the most frequently isolated pathogens. Other microbes included *Candida* spp., *Proteus mirabilis*, *Enterococcus faecalis*, *Staphylococcus saprophyticus*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*. The presence of a pathogen in a urine sample, in the absence of additional signs of infection, should not be considered sufficient for diagnosis or used as a basis for initiating antibiotic therapy, given the high likelihood that the organism reflects catheter colonization rather than true infection [7, 9, 10].

Symptoms

Urinary tract infections can present with a range of non-specific symptoms in patients with indwelling urinary catheters, posing a diagnostic challenge. Common clinical manifestations include lower abdominal and pelvic discomfort or pain, as well as systemic symptoms such as fever, chills, nausea, and vomiting. In cases with upper urinary tract involvement, flank pain and tenderness in the costovertebral angle may be experienced, indicating kidney involvement. Critically ill individuals often have limited ability to communicate due to the severity of their condition, impaired or fluctuating levels of consciousness, endotracheal intubation, or complete loss of verbal contact. As a result the symptoms may not be clearly expressed by these patients, which can pose a diagnostic challenge. In such cases, medical personnel should rely on indirect indicators. These include changes in urine appearance, such as discoloration or turbidity, reduced urine output in the catheter bag, and a general decline in clinical status. In intubated patients, worsening of mechanical ventilation parameters may also serve as an early warning sign. The presentation of symptoms in catheterised patients can be subtle or atypical, underscoring the importance of thorough clinical assessment and timely symptom recognition to enable prompt diagnosis and appropriate treatment, thereby preventing further complications [3, 7].

Risk factors

ICU patients are at increased risk of developing CAUTIs due to a combination of patient- and treatment-related factors, including corticosteroid therapy, immunosuppression, antibiotic exposure, and baseline immune impairment resulting from critical illness. Additional risk factors include prolonged catheterization, diabetes, a history of prior catheterization, as well as extended hospital and ICU stays [11, 12].

Diagnostic methods

The U.S. Centers for Disease Control and Prevention (CDC) has established a set of diagnostic criteria for CAUTIs. In order to meet these criteria, a patient must have had an indwelling urinary catheter in place for a period of more than two consecutive days in an inpatient setting. Furthermore, the catheter must either remain in situ on the day the infection is identified or have been removed no more than one day prior. In addition to the catheterization requirements, the patient must exhibit at least one clinical symptom indicative of infection, such as fever exceeding 38.0°C, suprapubic tenderness, costovertebral angle pain or tenderness, urinary urgency, increased urinary frequency, or dysuria. Microbiological confirmation is also required, with urine culture identifying no more than two microbial species, at least one of which must be a bacterial strain present at a concentration of ≥105 colony-forming units (CFU) per millilitre. To confirm the presence of CAUTI, all diagnostic criteria must be fulfilled within a defined timeframe known as the Infection Window Period (IWP).

Accurate identification of CAUTI is essential for ensuring appropriate antimicrobial therapy, implementing infection control measures, and minimising the burden of catheter-related infections in hospitalized patients [8].

Urine collection for microbiological analysis should be performed via a newly inserted catheter. The sample must be obtained into a sterile container, adhering to strict aseptic technique, and the catheter port membrane should be disinfected prior to puncture. Disconnecting the catheter from the collection bag or obtaining urine directly from the bag is not recommended. In clinical practice, closed drainage systems are preferred, as they minimize the risk of infection. To ensure a representative sample, approximately 30 mL of urine should be collected immediately after catheter replacement [13].

Various diagnostic methods are employed to identify UTIs, including traditional techniques such as phenotypic biochemistry or culture-based identification. However, the latter modality can be time-consuming due to the time required for bacterial growth. Alternatively, PCR or immunoassay techniques offer rapid results; however, PCR may be affected by background contamination from external sources of DNA. Quantitative urine culture is considered the gold standard, yet results typically require approximately 24 hours, with antibiotic susceptibility testing requiring an additional 24 hours. Surface-enhanced Raman spectroscopy (SERS) is a promising tool for pathogen detection and identification. However, its current application is limited by restricted availability and insufficient number of reference Raman spectra of known bacterial species. Further research of a more extensive spectral library is needed before SERS can be routinely implemented in the clinical diagnosis of UTIs [14].

Treatment

In the treatment of CAUTI, the initial step involves removal of the urinary catheter alongside the initiation of antibiotic therapy. Catheter use should be minimized and discontinued as soon as it is no longer clinically necessary. For patients who continue to require a catheter, intermittent catheterization is recommended to help reduce microbial colonization prior to commencing antibiotic therapy. It is essential to obtain a urine culture before initiating antibiotics, particularly if the catheter has been in place for over two weeks [3, 7]. The initial empirical treatment of CAUTI should include broad-spectrum antibiotics selected on the basis of local antimicrobial susceptibility patterns. This approach is crucial for addressing a wide range of potential pathogens while awaiting definitive culture results. Once urine culture findings are available, it is essential for clinicians to promptly adjust the antibiotic regimen to target the identified microorganism and its resistance profile, thereby ensuring treatment efficacy.

It is well-established that the commencement of therapy with inappropriate broad-spectrum antibiotics can lead to an increased risk of adverse outcomes, including higher rates of complications and mortality. It is therefore important to carefully consider local resistance patterns and make timely therapy modifications based on culture results to ensure effective clinical management of this patient population [15].

For first-line treatment of complicated UTIs, fluoroquinolones such as ciprofloxacin or levofloxacin (IV), as well as ceftriaxone (IM or IV) or cefotaxime (IV), are recommended. Once antibiogram becomes available, the therapy should be adjusted according to the susceptibility profile of the isolated pathogen. In cases of clinical non-response or if antibiogram results are unavailable, second-line therapy includes piperacillin-tazobactam (IV) or aminoglycosides, such as gentamicin or amikacin (IV). Third-line treatment, reserved for severe or multidrug-resistant infections, involves the administration of carbapenems [16, 17].

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