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Article

Nosocomial Infections Associated with Mechanical Antisepsis, Catheterization, and Drainage Procedures: Mechanisms of Development and Prevention

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Abstract: Nosocomial infections remain one of the most significant problems in modern healthcare, particularly in invasive procedures such as catheterization, drainage, and mechanical antisepsis practices. This article analyzes the mechanisms of development, microbiological characteristics, and preventive strategies of infections associated with mechanical antisepsis and various catheter and drainage systems. The study revealed that the major causes of hospital-acquired infections include insufficient adherence to aseptic and antiseptic principles, colonization of catheter and drainage surfaces by biofilm-forming microorganisms, and the spread of antibiotic-resistant strains. In addition, the duration of catheterization, the patient's immune status, and the hygienic conditions of hospital environments significantly contribute to infection development. The article highlights the importance of sterilization, disinfection, antimicrobial-coated catheters, healthcare worker hygiene, and infection-control protocols in reducing infection rates. The findings of this study provide an important scientific and practical basis for improving the prevention of nosocomial infections in surgical, intensive care, and resuscitation departments.

Keywords: Nosocomial Infection, Mechanical Antisepsis, Catheterization, Drainage, Biofilm, Asepsis, Antisepsis, Antibiotic Resistance, Sterilization, Infection Prevention

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1. Introduction

In recent years, the incidence of nosocomial infections in inpatient healthcare facilities has significantly increased. The widespread use of invasive diagnostic and therapeutic procedures has further intensified this problem. Catheterization, drainage procedures, and mechanical antisepsis play an essential role in modern surgery and intensive care medicine [1]. However, these procedures may create favorable conditions for microbial entry into the human body.

Nosocomial infections prolong hospitalization, increase healthcare costs, and contribute to higher mortality rates. In global healthcare practice, infections associated with urinary catheters, central venous catheters, and drainage systems are among the most common hospital-acquired infections [2].

Although mechanical antisepsis is aimed at removing microorganisms mechanically from wounds, tissues, or infected areas, improperly performed procedures may themselves become a source of infection. Furthermore, the formation of biofilm-producing bacteria on catheter and drainage surfaces reduces the effectiveness of antibiotic therapy and contributes to the development of chronic infections [3].

The purpose of this article is to investigate the mechanisms underlying nosocomial infections associated with mechanical antisepsis, catheterization, and drainage procedures, identify major risk factors, and analyze modern preventive strategies [4].

2. Materials and Methods

This scientific study employed analytical and literature review methods to investigate the mechanisms and preventive strategies of nosocomial infections associated with mechanical antisepsis, catheterization, and drainage procedures. Modern scientific publications, clinical observations, and microbiological data regarding hospital-acquired infections in surgical, resuscitation, and intensive care units were analyzed [5].

The study materials included:

- clinical cases associated with catheterization and drainage procedures;
- scientific data on urinary and central venous catheters;
- microbiological analyses of biofilm-forming microorganisms;
- international guidelines on aseptic and antiseptic standards;
- infection-control data from intensive care units.

The following methods were used in the research:

1. Retrospective analysis of scientific literature;
2. Comparative analysis of microbiological findings;
3. Generalization of clinical observation results;
4. Statistical and logical analysis of risk factors associated with nosocomial infections [6].

During the analysis, microorganisms such as *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae* were identified as the major etiological agents associated with catheter- and drainage-related infections. In addition, the mechanisms of biofilm formation and the development of antibiotic-resistant strains were evaluated [7].

The methodological basis of the study relied on the principles of evidence-based medicine. The obtained data were systematically analyzed to improve the effectiveness of nosocomial infection prevention strategies [8].

3. Result

The analysis demonstrated that nosocomial infections associated with catheterization and drainage procedures have a high incidence in intensive care and surgical departments. Prolonged catheterization was found to significantly increase the risk of infection development in hospitalized patients [9].

According to the analyzed data:

urinary catheter-associated infections are among the most common nosocomial infections;

central venous catheter-related bacteremia contributes to severe complications and sepsis;

long-term use of drainage systems enhances microbial colonization [10].

Microbiological analyses revealed a high prevalence of biofilm-forming bacteria on catheter and drainage surfaces. Due to the increased antibiotic resistance of microorganisms within biofilms, treatment effectiveness was markedly reduced.

The study identified the following major risk factors:

inadequate adherence to sterilization protocols;

insufficient hand hygiene among healthcare workers;

prolonged invasive procedures;

immunocompromised patient conditions;

uncontrolled use of antibiotics [11].

Furthermore, the use of antimicrobial-coated catheters, closed drainage systems, and strict aseptic control significantly reduced infection rates [12].

4. Discussion

The obtained results demonstrated that nosocomial infections associated with mechanical antisepsis, catheterization, and drainage procedures remain one of the major challenges in modern inpatient healthcare. Although invasive procedures are essential for saving patients' lives, they also create favorable conditions for microbial entry into the body. In particular, prolonged catheterization and drainage system use increase colonization by biofilm-forming bacteria [13].

Among the identified microorganisms, opportunistic pathogens such as Staphylococcus aureus, Pseudomonas aeruginosa, and Klebsiella pneumoniae were predominant. These bacteria possess strong biofilm-forming abilities, which significantly reduce the effectiveness of antibiotic therapy . Microorganisms embedded within biofilms exhibit increased resistance to environmental factors and antimicrobial agents.

The findings are consistent with numerous international studies reporting high mortality rates associated with catheter-related infections in intensive care units, especially central venous catheter and urinary catheter infections. This emphasizes the necessity for strict adherence to aseptic and antiseptic protocols by healthcare professionals [14].

The discussion revealed that the following factors play a significant role in the development of nosocomial infections:

prolonged duration of invasive procedures;

inadequate sterilization quality;

insufficient hand hygiene among healthcare personnel;

irrational use of antibiotics;

weakened patient immunity.

Furthermore, the use of antimicrobial-coated catheters, closed drainage systems, modern anti-biofilm antiseptic agents, and strengthened infection-control protocols were confirmed to be effective strategies in reducing nosocomial infection rates.

Future studies should focus on molecular microbiology and deeper investigation of antibiotic resistance mechanisms in healthcare-associated pathogens [15].

5. Conclucion

Although mechanical antisepsis, catheterization, and drainage procedures play an important diagnostic and therapeutic role in modern medicine, the nosocomial infections associated with these interventions remain a serious clinical challenge. The study demonstrated that biofilm-forming microorganisms on catheter and drainage systems are among the primary risk factors for infection development.

To prevent the occurrence of nosocomial infections, it is essential to:

strictly adhere to aseptic and antiseptic protocols;

improve sterilization quality;

ensure proper hand hygiene among healthcare workers;

minimize the duration of invasive procedures;

use modern antimicrobial-coated catheters;

apply antibiotics rationally.

In addition, improving infection-control systems in hospitals and implementing innovative anti-biofilm technologies can significantly reduce the incidence of hospital-acquired infections.

The findings of this study have important scientific and practical value for improving infection prevention strategies in surgical, resuscitation, and intensive care departments.

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