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PSEUDOMONAS AERUGINOSA: ANTIBIOTIC RESISTANCE, VIRULENCE, AND CLINICAL SIGNIFICANCE

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Abstrac: Pseudomonas aeruginosa is an opportunistic pathogen widely distributed in the environment and can cause severe infections, particularly in patients who are immunocompromised, have burn injuries, or use invasive medical devices. This article reviews the bacterium's main biological characteristics, virulence factors, biofilm formation, and mechanisms of antibiotic resistance based on the literature. Preventive approaches relevant to clinical practice and food safety are also discussed. This article is a literature review and does not present new laboratory experiments or data obtained from patients.

Keywords: Pseudomonas aeruginosa, antibiotic resistance, biofilm, virulence, healthcare-associated infection, food safety.

Introduction

The spread of microorganisms resistant to antimicrobial agents is an important factor complicating the treatment of infections. P. aeruginosa is found in water, soil, and various moist environments; it can also persist in healthcare facilities and cause infections in vulnerable individuals. The clinical significance of this bacterium is associated with its adaptability, production of various virulence factors, and ability to develop resistance to several antibiotic classes (Streeter and Katouli, 2016; Horcajada et al., 2019).

AIM AND METHODS

The aim of this article is to summarize the pathogenic properties of P. aeruginosa, its mechanisms of antibiotic resistance, and its significance for infection control. The work was prepared as a narrative literature review: information from scientific sources on bacterial virulence, biofilm formation, clinical infections, and food-related aspects was compiled by topic. No independent microbiological testing or statistical analysis was performed.

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BIOLOGICAL CHARACTERISTICS AND VIRULENCE

P. aeruginosa is a Gram-negative, rod-shaped bacterium that is generally motile and grows well under aerobic conditions. It can adapt to various environments and, under certain conditions, can also survive in oxygen-limited locations by using nitrate. Its pigment production in the laboratory and its biochemical characteristics can help distinguish it from other microorganisms (Diggle and Whiteley, 2020).

The pathogenicity of the bacterium is not determined by a single factor. Its outer-membrane lipopolysaccharide, pili, and flagella contribute to tissue attachment and motility. Extracellular enzymes and toxins can damage host tissues and weaken immune defense mechanisms. The expression of virulence factors is also regulated by chemical signaling between bacterial cells (Lee and Zhang, 2015; Rocha et al., 2019).

BIOFILMS AND TREATMENT CHALLENGES

P. aeruginosa can attach to surfaces and form biofilms consisting of cells and extracellular polymeric substances. Biofilms protect bacteria from external stresses, alter their physiological state, and may reduce the effectiveness of antimicrobial agents. For this reason, biofilms are important in infections associated with catheters, ventilatory equipment, and other medical devices (Stewart and Costerton, 2001; Ryder et al., 2007).

Antibiotic resistance can arise through several mechanisms: production of enzymes that break down or modify antibiotics, reduced outer-membrane permeability, active efflux pumps, and changes in target structures. Under biofilm conditions, slower bacterial growth and survival within a protected microenvironment can also make treatment more difficult. Resistance profiles may vary by strain and healthcare facility; therefore, treatment should not be selected solely on the basis of general information. In clinical cases, microbiological culture and antimicrobial susceptibility testing should support clinical decision-making (Horcajada et al., 2019; Rocha et al., 2019).

SIGNIFICANCE FOR CLINICAL PRACTICE AND FOOD SAFETY

P. aeruginosa can cause pneumonia, bloodstream infections, urinary tract infections, and wound infections. The risk of severe disease is higher in immunocompromised patients, people with burn injuries, and patients in intensive care. The bacterium’s persistence in aqueous environments and ability to form biofilms on surfaces make careful cleaning, disinfection, and infection control particularly important in healthcare facilities.

Within the food chain, Pseudomonas species can contribute to the spoilage of chilled meat, poultry, and dairy products. In addition to reducing product quality, this highlights the importance of hygienic control during production and storage. The detection of Pseudomonas in food should not always be interpreted as direct evidence of disease; risk assessment depends on the microorganism species, the product, and the conditions of contamination (Raposo et al., 2017; Xu et al., 2019).

DISCUSSION AND PRACTICAL RECOMMENDATIONS

The literature indicates that controlling P. aeruginosa involves more than selecting an antibiotic. Infection control also requires hand hygiene, proper care of medical devices, monitoring of water and damp surfaces, and microbiological surveillance where appropriate. In food production, separating

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raw materials from finished products, following sanitation procedures, and maintaining an uninterrupted cold chain can reduce the risk of spoilage. The prudent use of antibiotics and regular monitoring of local resistance data can help improve treatment effectiveness.

CONCLUSION

The clinical risk posed by Pseudomonas aeruginosa is explained by its adaptability, multiple virulence factors, ability to form biofilms, and diverse antibiotic-resistance mechanisms. Effective control requires the combined use of laboratory diagnostics, antimicrobial susceptibility testing, infection prevention, and hygiene measures. This article summarizes the available literature; clinical decisions should be made based on the patient's condition and current clinical guidelines.

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