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Review Article

Bacterial Conjunctivitis in Humans and Animals: Pathogen Profiles and Antibiotic Resistance from a One Health Perspective

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Abstract: Bacterial conjunctivitis is a widespread ocular infection affecting both humans and animals, commonly caused by pathogens such as *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Streptococcus pneumoniae*, and *Haemophilus influenzae*. This review examines the similarities in etiologies, clinical features, and the growing challenge of antibiotic resistance observed in conjunctival infections across species. Notably, the emergence of resistant strains, including methicillin-resistant *Staphylococcus aureus* (MRSA) and multidrug-resistant *Pseudomonas aeruginosa*, has complicated treatment efforts and increased public health concerns. The rising rates of resistance highlight the urgent need for coordinated surveillance systems and more prudent antibiotic use. Employing the One Health approach, which recognizes the intrinsic links between human, animal, and environmental health, provides valuable insights into the mechanisms of resistance development, transmission pathways, and risks of zoonotic and reverse zoonotic infections. Gaining a thorough understanding of these interactions is crucial for designing effective management strategies, improving diagnostic protocols, and promoting responsible antimicrobial stewardship in both medical and veterinary fields. A unified effort is necessary to address the evolving threat of antibiotic-resistant conjunctival pathogens.

Keywords: Bacterial conjunctivitis, antibiotic resistance, One Health, MRSA, multidrug-resistant Pseudomonas aeruginosa.

INTRODUCTION

Bacterial conjunctivitis is a common inflammatory condition of the conjunctiva, the transparent membrane covering the white part of the eye and the inner eyelids. It is caused by various bacterial pathogens and is characterized by clinical signs such as eye redness, mucopurulent discharge, tearing, irritation, and eyelid swelling. This condition affects both humans and animals, with a higher prevalence observed in children, immunocompromised individuals, and companion animals such as cats and dogs (Azari & Barney, 2013; Sweeney *et al.*, 2022). The most frequently implicated bacterial species include *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Streptococcus pneumoniae*, and *Haemophilus influenzae* (Davis *et al*., 2021; McDonald *et al.*, 2022).

Although bacterial conjunctivitis is generally self-limiting or treatable with topical antibiotics, the increasing global challenge of antibiotic resistance has made the management of ocular infections more complex. Resistance to commonly used antibiotics such as fluoroquinolones, macrolides, and aminoglycosides has been reported in ocular isolates from both human and animal sources (Wu *et al.*, 2021). This resistance not only prolongs recovery time but also increases the risk of complications and treatment failure.

The misuse and overuse of antibiotics—such as the inappropriate prescribing of broad-spectrum antimicrobials and the prophylactic use in veterinary medicine—have contributed significantly to the rise in resistant ocular pathogens (Miller *et al.*, 2018; Li *et al.*, 2023). Furthermore, the widespread availability of over-the-counter eye drops without proper diagnosis exacerbates the issue, especially in resource-limited settings.

In response to this growing public health threat, the One Health concept has emerged as a holistic approach that recognizes the interconnection between human, animal, and environmental health. This approach advocates for integrated surveillance, antibiotic stewardship, and collaborative efforts among medical, veterinary, and environmental health professionals to curb the spread of resistance (Jackson *et al.*, 2021; World Health Organization, 2023).

This review aims to explore the etiology and antibiotic resistance profiles of bacterial conjunctivitis pathogens in both humans and animals. By comparing resistance patterns across species, we aim to highlight the shared challenges and the need for unified strategies to mitigate the impact of antibiotic resistance in ocular health.

2. Common Pathogens in Humans and Animals

Bacterial conjunctivitis affects a broad range of hosts, including humans and various animal species. Several pathogens are shared between both groups, reflecting the zoonotic and reverse zoonotic potential of ocular infections, as shown in (Figure1). This figure highlights the pathogen profiles involved in conjunctivitis across humans and animals, alongside their associated antibiotic resistance patterns from a One Health perspective.

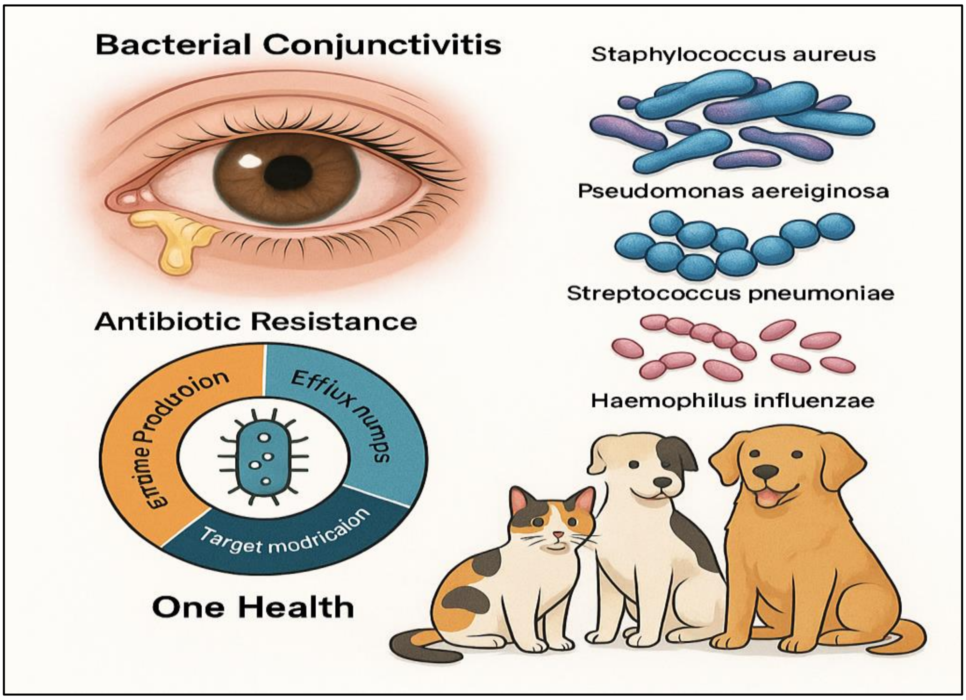

Figure 1: Common bacterial pathogens causing conjunctivitis in humans and animals, and associated antibiotic resistance mechanisms, from a One Health perspective

2.1 *Staphylococcus aureus*

Staphylococcus aureus is one of the most prevalent causative agents of conjunctivitis in both humans and animals. In humans, it is commonly associated with hospital-acquired infections and chronic blepharoconjunctivitis. In animals, particularly dogs and cats, it causes recurrent eye infections and is often linked to concurrent dermatological conditions (Smith & Brown, 2020). The emergence of methicillin-resistant *Staphylococcus aureus* (MRSA) in both clinical and veterinary settings has become a critical concern, limiting treatment options and increasing the risk of treatment failure (Wilson *et al.*, 2020).

2.2 *Pseudomonas aeruginosa*

Pseudomonas aeruginosa is a Gram-negative opportunistic pathogen known for its intrinsic resistance mechanisms and environmental adaptability. It is a major cause of acute and chronic ocular infections in humans, particularly in contact lens users and hospitalized patients (Thomas *et al.*, 2019). While less frequently isolated from animals, it can cause conjunctivitis and keratitis in immunocompromised pets or those with compromised ocular surfaces (Evans & Hunter, 2018).

2.3 *Streptococcus pneumoniae*

Streptococcus pneumoniae is a significant pathogen in pediatric conjunctivitis and is often isolated from cases of epidemic conjunctivitis in schools and daycare centers (Johnson & Williams, 2019). In veterinary medicine, although less commonly reported, it has been identified in ocular infections in species such as horses and laboratory primates, suggesting a potential for interspecies transmission under certain conditions (Patel & Sharma, 2020).

2.4 *Haemophilus influenzae*

Haemophilus influenzae is a major pathogen in human conjunctivitis, especially in children, and is known for its role in conjunctivitis-otitis syndrome (Davis *et al.*, 2021). Although rarely reported in animals, zoonotic strains have been detected in domestic environments, posing potential occupational risks to veterinary personnel and pet owners (Miller *et al.*, 2018).

3. Antibiotic Resistance Mechanisms

The development of antibiotic resistance in bacterial conjunctivitis pathogens represents a serious public health challenge. Several genetic and biochemical mechanisms are responsible for this phenomenon:

3.1 Enzyme Production (β-lactamases)

Many bacteria, including *S. aureus*, produce β-lactamases, enzymes capable of hydrolyzing β-lactam antibiotics such as penicillins and cephalosporins. These enzymes confer resistance by breaking down the antibiotic before it can exert its bactericidal effect (Chambers & DeLeo, 2020). Extended-spectrum β-lactamases (ESBLs) have also been identified in *P. aeruginosa* and other ocular isolates, further complicating treatment (Rodriguez *et al.*, 2022).

3.2 Efflux Pumps

Efflux pumps are transport proteins that actively expel antibiotics out of bacterial cells, reducing intracellular drug concentrations. This mechanism is particularly relevant in *P. aeruginosa*, which expresses multiple efflux systems (e.g., MexAB-OprM) that contribute to multidrug resistance (Poole, 2019).

3.3 Target Modification

Some bacteria alter the target sites of antibiotics, such as penicillin-binding proteins or ribosomal subunits, to prevent effective drug binding. For example, *S. pneumoniae* can undergo genetic mutations leading to changes in penicillin-binding proteins (PBPs), which reduces β-lactam susceptibility (Garcia-Cobos *et al.*, 2021).

4. The One Health Perspective

The One Health approach emphasizes the interdependence of human, animal, and environmental health, particularly in the context of antimicrobial resistance. Given the shared microbiota and close interactions between pets and their owners, the potential for cross-species transmission of resistant ocular pathogens is substantial.

4.1 Zoonotic Transmission

Close contact with infected animals or contaminated surfaces can facilitate the exchange of resistant bacteria such as *S. aureus* and *P. aeruginosa* between humans and animals (Jackson *et al.*, 2021). Shared environments, such as households, animal shelters, or veterinary clinics, further increase the risk of transmission.

4.2 Antimicrobial Use in Animals

The routine use of antibiotics in veterinary practice—often without culture-based diagnosis—has been implicated in the emergence of resistant strains that may affect both animal and human health (OIE, 2023). Inappropriate prophylactic use in food animals and pets can lead to the selection and persistence of resistant genes in the environment.

4.3 Integrated Surveillance and Stewardship

Adopting a One Health model supports collaborative surveillance programs to monitor antibiotic resistance trends across species. It also promotes responsible antibiotic use through stewardship initiatives involving both human and veterinary professionals (World Health Organization, 2023). Coordinated policies and guidelines are essential for reducing the emergence and spread of resistant pathogens.

5. CONCLUSION

Bacterial conjunctivitis poses a significant public health and veterinary concern, particularly in light of increasing antibiotic resistance. Shared pathogens between humans and animals highlight the importance of cross-species surveillance and a One Health approach to disease management. The mechanisms of resistance—such as β-lactamase production, efflux pumps, and target modification—are prevalent in both human and animal isolates, complicating treatment efforts. Inappropriate antibiotic use in veterinary and medical fields accelerates the emergence of resistant strains, emphasizing the urgent need for antibiotic stewardship and coordinated action. A collaborative, interdisciplinary effort involving physicians, veterinarians, microbiologists, and public health professionals is essential to mitigate the risks and improve clinical outcomes. Continued research and integrated monitoring systems are key to controlling the spread of resistant ocular pathogens and protecting both human and animal health.

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