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BACTERIAL EAR INFECTION MEDIATED BY NEUTROPHILIC GRANULOCYTES

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ABSTRACT

Microorganisms such as bacteria, viruses, and fungi can cause ear infections. Common bacterial ear infections trigger an immune response that begins with neutrophils arriving at the site of infection. Inflammation caused by microorganisms is mediated by immune cells. Neutrophils are recruited to the site of infection in response to signaling molecules such as cytokines and chemokines. They ingest bacteria, digest them, and release granules containing antimicrobial peptides that help eliminate the bacteria. Therefore, bacterial infections of the ear and, especially the middle ear, activate immune processes. Among the inflammatory mediators that are generated and released are cytokines and chemokines that are produced through protein synthesis. Reactive oxygen species (ROS) and products of arachidonic acid such as prostaglandins and leukotrienes also contribute to the inflammatory network. The immune system recognizes bacterial antigens through pattern recognition receptors (PRRs), such as Toll-like receptors (TLRs), located on immune cells in the inflamed ear. It can be concluded that middle ear infections cause inflammation through bacterial activation starting from neutrophils, followed by the involvement of other innate immune cells, and the activation of the adaptive immune system, including various types of T cells and B cells.

KEYWORDS: *Neutrophil, granulocyte, ear infection, otitis media, bacteria*

INTRODUCTION

Ear infections are common and can be caused by bacteria, viruses, or even fungi (1) (Table I). They are classified into three types: otitis externa, also known as "swimmer's ear," which is an infection that affects the outer ear canal; otitis media, which is an infection of the middle ear that is commonly seen in children; and otitis interna, also known as labyrinthitis, which affects the inner ear.

Table I. *Common causes of ear infections.*

Bacteria	*Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Moraxella catarrhalis*.
Viruses	Respiratory syncytial virus (RSV), influenza, and rhinoviruses.
Fungi (less common)	*Aspergillus* and *Candida* (particularly in individuals with compromised immunity or chronic conditions).

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Various factors can affect the immune response and risk of developing an ear infection. Young children are more susceptible to infections due to an immature immune system and anatomical differences (e.g., shorter Eustachian tubes) and certain vaccines, such as the pneumococcal conjugate vaccine, can reduce the incidence of bacterial ear infections. Additionally, chronic conditions, including allergies or immune deficiencies, can increase susceptibility and environmental factors, such as exposure to smoke, pollution, and allergens, can compromise ear health and immunity.

Bacterial ear infection activates an immune response that begins with neutrophils, leading to inflammation and damage to the auditory system (2) (Table II). Understanding the role of the immune system in preventing and combating these infections is crucial. Otitis media caused by bacterial infection is common and involves complex immunological and biochemical responses.

Table II. *The immune response following ear infection.*

Innate immune response	a) The first line of defense includes physical barriers (e.g., earwax, skin).
	b) Antimicrobial peptides present in earwax and mucosal surfaces.
	c) Immune cells such as neutrophils and macrophages respond quickly to infection.
Adaptive immune response	a) Humoral response (B cells produce antibodies that target specific pathogens).
	b) Cell-mediated response (T cells help in recognizing and eliminating infected cells).

Bacterial or viral infections can appear during a flu illness and cause otitis media, which includes acute otitis media, otitis media with effusion, and chronic suppurative otitis media (3,4). The involvement of neutrophilic granulocytes, inflammation, and cytokines plays a significant role in the body's defense mechanisms (5). In this regard, it is necessary to take a closer look at the dynamics of bacterial ear infections.

Neutrophil granulocytes, or simply neutrophils, are a type of white blood cell that are most abundant in the bloodstream (about 70%) and are among the first to respond to bacterial infections (6). In the case of a bacterial ear infection, neutrophils are rapidly recruited to the site of infection in response to signaling molecules such as cytokines and chemokines (7). Neutrophils are one of the first responders to infections. They migrate from the bloodstream into the infected tissue via diapedesis and engulf and digest bacteria through the process of phagocytosis. They release inflammatory granules containing antimicrobial peptides and enzymes that help destroy the bacteria (6).

DISCUSSION

Inflammation is a defensive immune reaction against pathogens that occurs in bacterial ear infections to improve the pathological tissue state (8). Inflammation is mediated by the release of chemical mediators from immune cells, including neutrophils. The most common mediators that enhance the inflammatory response include cytokines (such as TNF, IL-1, and IL-6), chemokines, prostaglandins, histamine, and reactive oxygen species (ROS) (9). Neutrophils produce ROS that are important for killing bacteria, but because they are inflammatory cells, they can also cause tissue damage (10).

Bacterial ear infection leads to the activation of biochemical processes, including the generation of arachidonic acid compounds with the production of inflammatory products such as prostaglandins and leukotrienes, and the activation of the complement system which enhances the antibody effect and helps with phagocytosis to eliminate bacteria and decaying cells (11).

Ear infections are often caused by bacteria, the most common being *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Pseudomonas aeruginosa* (12). Bacterial antigens are recognized by the immune system through pattern recognition receptors (PRRs) such as Toll-like receptors (TLRs) located on immune cells in the ear (13).

PRRs, including TLRs, which recognize pathogen-associated molecular patterns (PAMPs) on bacteria, trigger the immune response (14) (Table III). Activation of PRRs triggers intracellular biochemical signaling, leading to activation of NF-kB and the secretion of inflammatory cytokines and chemokines (15). Endothelial cells are also involved in these processes, regulating the adhesion molecules ICAM-1 and VCAM-1, which are implicated in neutrophil migration to the site of infection (16). The cytokines TNF, IL-1β, and IL-6, with the chemokine IL-8, are key mediators in the immune response to bacterial infections and are produced by activated immune cells (17,18). They play a crucial role in recruiting neutrophils and other immune cells to the site of infection. However, there are also non-inflammatory cytokines such as IL-10 and TGF-β that help regulate and resolve inflammation, preventing serious tissue damage (19).

Table III. *Physiopathology of bacterial ear infections.*

i. Entry of pathogens	Bacteria enter the ear, often through the Eustachian tube, leading to colonization and infection.
ii. Immune activation	Recognition of bacteria by pattern recognition receptors (PRRs) on epithelial cells and resident immune cells triggers the release of cytokines and chemokines.
iii. Neutrophil recruitment	Certain cytokines and chemokines (such as IL-8) attract neutrophils to the infection site.
iv. Inflammatory response	Neutrophils and other immune cells release inflammatory mediators, leading to tissue edema, pain, and other symptoms of inflammation.
v. Bacterial clearance	Neutrophils phagocytose bacteria and release antimicrobial substances.
vi. Resolution	Anti-inflammatory cytokines and other regulatory mechanisms resolve the inflammation, and tissue repair processes begin.

There are various methods of treatment for bacterial ear infections. Obviously, if it is a bacterial infection, appropriate antibiotics are used, while if the infections are viral, they are often not treated as they resolve on their own (20). Fungal infections can be treated with anti-fungal medications and a diet rich in vitamins and minerals in order to help the immune system (21).

CONCLUSIONS

Bacterial ear infections are mediated by neutrophilic granulocytes that arrive at the infection site and induce an inflammatory response. The cascade of inflammatory molecules is fueled by the activation of immune cells that release cytokines, chemokines, arachidonic acid products, ROS, and chemical mediators, including histamine. Bacterial treatment involves antibiotics that help resolve the infection and thus, the inflammation.

Conflict of interest

The authors declare that they have no conflict of interest.

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