Literature Review
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Streptococcus iniae: an emerging foodborne pathogen: a mini review

Abstract

Emerging zoonotic pathogens are important causes of morbidity and mortality both in humans as well as in animals and are reported in developing and developed nations. *Streptococcus iniae* is an emerging zoonotic pathogen primarily affecting aquaculture, causing significant morbidity and economic losses in farmed fish worldwide. This bacterium, which thrives in stressed and densely stocked aquaculture environments, has zoonotic potential, particularly for those handling or preparing infected fish. The source of infection is exogenous and ingestion is considered the main mode of transmission. Human infections, while sporadic, can result in serious conditions like bacteremia, meningitis, and endocarditis. Laboratory help is required to confirm an unequivocal diagnosis of disease. We recommend biosecurity in aquaculture, public education on safe handling, and alternative disease control strategies to mitigate risks. Current research highlights the need for sustainable management, exploring options like vaccination and plant-based antimicrobials to reduce antibiotic resistance and improve public and aquatic health.

Keywords: bacterial infection, fish, foodborne zoonosis, public health, streptococcus iniae, zoonotic pathogen

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Introduction

There are several species of *Streptococcus* including *Streptococcus iniae*, *S. agalactiae*, *S. dysgalactiae*, *S. ictalurid, S. pyogenese, S. suis*, and *S. canis* which are implicated in the etiology of streptococcosis.[1–5] Among these, *Streptococcus iniae* emerged as a significant pathogen for both wild and farmed fish during the 1990s and 2000s, posing serious risks to global aquaculture and human health.[1,6] This Gram-positive bacterium can infect a variety of freshwater and marine species, such as *Oreochromis niloticus*, *Lates calcarifer*, *Amazon catfish*, *Acipenser baerii*, and *Oncorhynchus mykiss*.[7,8] Human diseases caused by these zoonotic bacteria are linked to handling and preparing contaminated fish. The first report of infections in humans was recorded in 1996.[9] In 2000, *Streptococcus iniae* was identified at the International Conference on New Infectious Diseases as a new zoonotic pathogen spread by food animals.[10] Despite being rare, *Streptococcus iniae* infections in humans are still being reported and in 2009, additional cases were discovered.[11]

The disease is characterized by enteritis,[12] generalized septicemia, and meningoencephalitis, [13] and causes a high mortality rate of about 50%.[14] In recent years, *Streptococcus iniae* has become one of the most important fish pathogens, causing hundreds of millions in losses to aquaculture every year.[15] In addition, *Streptococcus iniae* is also considered a zoonotic pathogen like other *Streptococcus* spp., especially for people with low immunity or associated with processing fresh fish.[16] In humans, *Streptococcus iniae* infection often causes bacteremic cellulitis, which subsequently leads to serious complications including arthritis, meningitis, endocarditis, and osteomyelitis.[17] Therefore the objective of this paper is to present a critical review of *Streptococcus iniae,* as an emerging foodborne pathogen of public health concern.

Literature review

Etiology

Streptococcus iniae, a Gram-positive, facultatively anaerobic bacterium, is a significant pathogen in aquaculture, responsible for severe infections in freshwater and marine fish, such as tilapia and trout. Originally isolated from a freshwater dolphin in the Amazon, *Streptococcus iniae* has become widespread, causing high morbidity and mortality in aquaculture settings. Its transmission is often linked to environmental factors, including handling stress and overcrowded conditions, which are common in aquaculture environments.[18] The bacteria's pathogenicity relies on various virulence factors. One of its primary defenses is a polysaccharide capsule, which protects it from host immune cells by preventing phagocytosis. Furthermore, *Streptococcus iniae* produces enzymes, such as streptolysin S, which damage host cells and support tissue invasion.[19] Additionally, the bacterium has specialized adhesion proteins that facilitate attachment to host tissues, a critical step in infection initiation. Genome analysis of *Streptococcus iniae* reveals genetic diversity among isolates, which may explain variations in pathogenicity and immune responses across different fish species.[20]

Pathogenesis

The pathogenesis of *S. iniae*, an emerging zoonotic pathogen primarily affecting fish and occasionally causing infections in humans, involves complex mechanisms that facilitate host invasion, immune evasion, and tissue damage. One critical aspect of *Streptococcus iniae* pathogenicity is its capsule, which impairs phagocytic clearance by the host immune cells, allowing it to evade early immune responses. This enables the bacterium to establish infections effectively in host tissues.[18] Additionally, *Streptococcus iniae* possesses specialized secretion systems, particularly the type VII secretion system (T7SS), found in various pathogenic Firmicutes. The T7SS in *Streptococcus iniae* facilitates the secretion of virulence factors that help in colonizing host tissues and competing with other microbial populations in the fish host, which is essential for its survival and proliferation within the host environment.[21] Moreover, specific genomic regions within *Streptococcus iniae*, such as the plasticity zone (PZ-I), contain genes encoding hypothetical proteins and enzymes that potentially support nutrient acquisition and adaptability within various host tissues, thus enhancing its pathogenic capabilities.[22] In human cases, the pathogen generally enters through skin abrasions, often due to handling infected

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fish, leading to soft tissue infections or even systemic diseases. *Streptococcus iniae* M-like protein and other surface proteins are instrumental in adhering to host cells and resisting immune responses, making it a formidable pathogen in both aquaculture and, occasionally, in human health contexts.[23]

Geographic distribution

Streptococcal disease occurs in all continents (Americas, Asia, Europe, Africa, and Australia). There have been reports of thousands of *Streptococcus* species worldwide, including *S. parauberis*, *S. suis*, *S. iniae*, *S. agalactiae*, *Lactococcus garvieae*, *S. dysgalactiae, S. pyogenese*, and *Varococcus salmoninarum*.[1,4,5] It is generally assumed that streptococcosis has a worldwide distribution, having been described in fish from Europe, the Americas, the Middle East, throughout Asia, and Australia.[1,24–25] *Streptococcus iniae* has, to date, mainly been reported in North America, the Caribbean, parts of Asia (e.g., Japan, China, Singapore, Taiwan), Australia, and the Middle East.[26]

Risk factors

The risk factors for *Streptococcus iniae* infections primarily stem from conditions in aquaculture that facilitate bacterial spread, such as high stocking densities, handling stress, and inadequate water quality control. Stress and crowded conditions weaken fish immunity, making them more susceptible to infections.[18] Moreover, antibiotic overuse in aquaculture as a control measure can contribute to antibiotic resistance in *S. iniae*, complicating treatment and potentially transferring resistance to other bacterial pathogens within the ecosystem. Antibiotic resistance is a growing concern due to its effects on both fish health and broader environmental and human health impacts.[19] Consequently, reliance on antibiotics is being questioned, and alternative solutions, such as vaccination and the use of plant-based antimicrobials, are being explored for sustainable management of *S. iniae* in aquaculture systems.[20]

Transmission

The main ways that *Streptococcus iniae* can infect humans are through contaminated fish contact or by consuming undercooked fish items. Cross-contamination during food preparation and handling is another risk factor for the spread of foodborne illness.[1] *Streptococcus iniae* can spread from fish to fish through carrier fish,[27] and since fish with obvious disease symptoms are seldom sold, these carriers may be the origin of human infection. When fresh fish is prepared from wet markets, soft tissue injuries typically cause bacteremic cellulitis of the hand, which is followed by more than one of the following conditions: endocarditis, meningitis, arthritis, sepsis, pneumonia, osteomyelitis, and toxic shock.[28] *Streptococcus iniae* is becoming more linked to human exposure through seafood eating because it grows well in aquatic habitats, especially in intensive aquaculture systems. Human interaction is more likely when the bacteria are present in fish farms, particularly as aquaculture production rises.[29]

Clinical signs

Streptococcus iniae is a zoonotic pathogen that causes cellulitis and bacteremia in humans.[9,30] Septic progression of infection can result in endocarditis, meningitis, arthritis, pneumonia, toxic shock, and osteomyelitis.[9,30–31] Manipulation of these organisms can cause soft tissue injuries through which the bacteria enter, leading to bacteremic cellulitis in the hand and other more serious conditions, such as endocarditis, meningitis, arthritis, sepsis, pneumonia, osteomyelitis, lymphangitis, bloodstream infection, and toxic shock.[10] While human infection may be opportunistic,[1] it has been associated with recent handling and preparation of infected fresh fish and disease has occurred in various locations worldwide.[30,32] Cases have been primarily reported in North America, the Middle East, the Asian-Pacific region, and Asia.[33]

Prevention and control

Public education on proper fish handling, thorough cooking, and aquaculture biosecurity measures is vital for preventing *Streptococcus iniae* infections. Regular monitoring and quality control in aquaculture can further reduce zoonotic transmission risks.[34,35]

Conclusion and recommendations

Streptococcus iniae poses a growing threat to both aquaculture and human health due to its zoonotic potential and its significant economic impact on fish farming. With infections affecting multiple fish species and transmission risks to humans during the handling and preparation of fish, *Streptococcus iniae* represents a critical pathogen. Effective management requires understanding its pathogenic mechanisms, geographic prevalence, and risk factors within aquaculture environments. To reduce *Streptococcus iniae* infections, rigorous biosecurity practices in aquaculture should be implemented, including proper stocking densities and water quality monitoring. Public education on safe fish handling, thorough cooking, and avoiding raw or undercooked fish is crucial to prevent human infections. Further research on alternative treatments, such as vaccines and plant-based antimicrobials, can provide sustainable control measures, addressing both infection rates in aquaculture and reducing potential antibiotic resistance risks.

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None.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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