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Cardio-Bacteriology-Insights into Bacterial Infections Affecting Cardiac Tissues and Valves

Mynumathi Maragatham[1], Geetha R[2]

[1]Assistant Professor, Department of Microbiology, PPG Institute of Allied Health Sciences, The Tamil Nadu Dr. M.G.R Medical University, Coimbatore - 641 035, India.
[2]Associate Professor, Department of Biochemistry, PPG Institute of Allied Health Sciences, The Tamil Nadu Dr. M.G.R Medical University, Coimbatore - 641 035, India.

Corresponding Author: Mynumathi Maragatham

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ABSTRACT

Over the past decade, the global landscape of cardiovascular infections has evolved, with an increasing prevalence of microbial pathogens contributing to the complexity and severity of heart diseases. This article explores the critical importance of microbiological identification in diagnosing and managing cardiovascular infections, which are often overlooked or misdiagnosed. By delving into a variety of reported cases from different countries, it highlights the alarming rise in the incidence of these infections, often exacerbated by the silent nature of microbial invaders. The study underscores how timely and precise microbial identification not only aids in the targeted treatment of cardiovascular infections but also provides deeper insights into the pathogen-host dynamics shaping the course of these diseases. In a world where cardiovascular health is a leading concern, the role of microbiology in cardiac care has never been more pivotal, demanding urgent attention and innovation in clinical practices to curb the growing burden of heart-related infections.

Keywords: cardiac Infections Myocarditis, Endocarditis, Diagnosis and Treatment, Heart Complications, Infective Endocarditis (IE)

INTRODUCTION

Cardiac infections refer to a group of conditions where the heart or its surrounding structures become infected by microorganisms, such as bacteria, viruses, fungi, or parasites. These infections can cause inflammation and damage to various parts of the heart, including the heart valves, the heart muscle, or the lining around the heart. The severity of cardiac infections can range from mild to life-threatening, depending on the area affected and how quickly treatment is initiated. Common types of cardiac infections include endocarditis, an infection of the heart valves and inner lining; myocarditis, inflammation of the heart muscle; pericarditis, inflammation of the sac surrounding the heart; Rheumatic heart disease, a severe sequela arising from inadequately treated streptococcal infections, manifests as chronic valvular damage resulting from an aberrant autoimmune response triggered by the initial infection. These infections may arise due to bacterial or viral causes, but fungal and parasitic infections can also affect the heart. Prompt diagnosis and treatment are crucial in managing cardiac infections, as untreated cases can lead to serious complications, such as heart failure,

valve damage, or even death. Understanding the causes, symptoms, and treatment options for these conditions is important for early intervention and effective care (1). Rheumatic fever, a delayed complication of pharyngitis and skin infections caused by group A Streptococcus, and Chagas disease (American trypanosomiasis), caused by the protozoan parasite Trypanosoma cruzi, are well-known for their cardiac involvement and are covered separately in this series. other infections, including: 1) viral infections (dengue, Zika, and Chikungunya); 2) protozoal infections (malaria, leishmaniasis, and human African trypanosomiasis [HAT]); 3) helminth infections (Echinococcosis, cysticercosis, and schistosomiasis); and 4) bacterial infections (tuberculosis). These infections can affect the cardiovascular system in various ways, including primary cardiac involvement (such as direct damage to myocardial cells, inflammation, or fibrosis of the myocardium, pericardium, and conduction system), as well as secondary involvement (due to factors like hypoxia, hypovolemia, and drug toxicity). Additionally, they can interact with pre-existing cardiovascular diseases (CVD). These cardiovascular manifestations often go unrecognized or are diagnosed too late, which can lead to severe consequences. Prompt identification and treatment are critical, as they can significantly improve outcomes, save lives, and help conserve limited healthcare resources (2,). "Viral heart disease" refers to a range of heart conditions caused by viruses, where the heart muscle cells (cardiac myocytes) are damaged, leading to impaired heart function, cell death, or both. Viruses that target the heart can also harm interstitial cells and cells within the blood vessels (3). Rhinovirus is a well-established cause of the common cold and has the potential to worsen various respiratory conditions. It belongs to the Picornaviridae family. In the past, rhinovirus was classified separately from enterovirus, but recent studies have led to its reclassification under the Enterovirus genus. While rhinovirus-associated myocarditis has been reported to the Centers for Disease Control and Prevention (CDC), this link has not yet been thoroughly documented or confirmed in scientific literature. This report details an uncommon clinical case characterized by the identification of rhinovirus infection in an adult patient, a presentation that is rarely documented in this age group. The case highlights the potential for rhinovirus to contribute to cardiac complications, a condition not often recognized in clinical practice. This case adds to the growing awareness of the possible cardiovascular effects of viral infections and underscores the need for further research into the connections between rhinovirus and myocarditis. Understanding these associations is crucial for improving diagnosis and treatment in affected individuals. Our findings suggest that rhinovirus could be a significant yet underappreciated factor in cardiac health, particularly in patients with existing pulmonary issue s(4). Parasitic infections, once geographically restricted to tropical regions of developing nations, are now increasingly identified across the globe due to the rise in international travel and human migration. These parasites may have direct or indirect effects on various structures of the heart, leading to conditions such as myocarditis, pericarditis, pancarditis, or pulmonary hypertension. As a result, it is increasingly important for healthcare providers in developed countries to consider parasitic infections in the differential diagnosis of heart-related diseases, regardless of geographic location. Among these, Chagas' disease being most significant parasitic infection that is affecting the heart, and it is now recognized as a global health issue due to the migration of people from endemic areas to regions where the disease was once uncommon. Advances in the treatment of African trypanosomiasis provide hope not only for preventing neurological complications but also for addressing the frequent cardiac

manifestations of this serious infection. Unfortunately, the absence of effective vaccines, optimal preventive treatments, and evidence-based pharmacological therapies for many parasitic heart diseases—particularly Chagas' disease—remains a major public health challenge. This gap in treatment options makes the fight against these infections critical to global health efforts (5).

Bacterial infections

Several bacterial infections have been identified in atherosclerotic plaques through the detection of nucleic acids or antigens. These include *Chlamydia pneumoniae* (Cp), *Mycoplasma pneumoniae*, *Helicobacter pylori* (H. pylori), *Enterobacter hormaechei*, as well as periodontal pathogens such as *Porphyromonas gingivalis* (P. gingivalis), *Aggregatibacter actinomycetemcomitans*, *Prevotella intermedia*, *Tannerella forsythia*, *Fusobacterium nucleatum*, *Streptococcus sanguis*, and *Streptococcus mutans*. These microorganisms have been implicated in the development of atherosclerosis, suggesting that bacterial infections may play a significant role in the formation and progression of arterial plaques. The detection of these bacteria within atherosclerotic lesions raises questions about their potential involvement in the inflammatory processes that contribute to cardiovascular disease. While research continues to explore the exact mechanisms, these findings highlight the complex relationship between infections and vascular health. Understanding this connection could open new avenues for preventive and therapeutic strategies aimed at reducing cardiovascular risk. The presence of these pathogens underscores the importance of considering infections in the pathogenesis of atherosclerosis and related heart conditions (6).

Invasive *Streptococcus pneumoniae* infections can lead to cardiac damage when the bacteria enter the bloodstream and attach to vascular endothelial cells, which then initiate damage to cardiomyocytes. This interaction results in the formation of small lesions near blood vessels in the heart, disrupting its electrical and contractile functions. When *S. pneumoniae* infiltrates cardiomyocytes, it forms antibiotic-resistant biofilms, making the infection harder to treat. These biofilms contribute to prolonged infection and increase the risk of lasting cardiac complications. This underscores the challenges of managing bacterial infections that directly impact heart function. *Clostridium difficile* is a widespread, strictly anaerobic bacterium known for its ability to form resilient spores. It can lead to severe clinical manifestations, especially in individuals with an imbalance in their intestinal microbiota. In rare cases, *C. difficile* has been linked to myocarditis, which is characterized by inflammation primarily driven by neutrophilic infiltration. This type of myocarditis often presents with significant myocardial damage. The presence of *C. difficile* in cardiac tissue highlights the diverse ways in which this pathogen can impact the body beyond the intestines (7).

Cardiac infections caused by the foodborne pathogen *Listeria monocytogenes* are a significant yet underexplored aspect of the disease. It remains unclear whether these cardiac infections are solely a result of the host's vulnerability or if certain bacterial strains have a natural affinity for cardiac tissue. In this study, we investigate the ability of a recent *L. monocytogenes* cardiac strain (07PF0776) to invade heart tissue, alongside nine other clinical and outbreak isolates. Mice infected with the cardiac strain 07PF0776 had ten times more bacteria in their heart tissue compared to those infected with *L. monocytogenes* strain 10403S, a well-known clinical isolate from a human skin lesion. Other *L. monocytogenes* strains displayed varying abilities to infect mouse heart tissue, with the most invasive strains also showing greater bacterial penetration in cultured myoblast cells. These findings strongly indicate that certain *L. monocytogenes*

strains have developed an enhanced ability to target and invade the heart, revealing a potentially important factor in the pathogenesis of cardiac infections (8).

Campylobacter fetus, the type species, has been identified as the cause of pericarditis in at least ten documented instances. In these cases, patients typically present with several weeks of vague symptoms, such as fever, weight loss, chest pain, and cough, but without gastrointestinal complaints. In contrast, pericarditis due to *C. jejuni* is an extremely rare occurrence, with only one reported case in a patient with X-linked agammaglobulinemia, a congenital immunodeficiency. This case involved a severe disease progression, requiring a 6-week hospitalization. *C. jejuni* was isolated from various sites, including blood cultures, pleural effusion, and pericardial effusion aspirates, during the investigation of systemic campylobacteriosis (9).

Mild, nonspecific chest pain is a common complaint among adolescents in general pediatric practice, often attributed to musculoskeletal issues. However, it is crucial to differentiate this from more serious, potentially life-threatening conditions. A thorough cardiac evaluation is necessary to assess the underlying cause of chest pain. One such case involved a previously healthy adolescent who presented with severe left-sided chest pain and abnormal ECG findings indicative of mycoplasma myocarditis. This highlights the importance of considering serious cardiac conditions, even in patients without prior health issues. Timely diagnosis and intervention are key to preventing complications in such cases. Comprehensive diagnostic workups, including ECG and cardiac imaging, are essential for appropriate management (10).

Lyme disease is caused by an infection with *Borrelia burgdorferi*, and one of its common cardiac manifestations is atrioventricular block. When patients present with wandering erythema and signs of abnormal heart function, especially if they have a history of travel to endemic areas or known tick exposure, Lyme disease myocarditis should be considered. The symptoms of myocarditis associated with Lyme disease are typically mild, transient, and often resolve on their own. However, early detection and treatment are crucial for a positive outcome. In most cases, if recognized promptly, the prognosis for Lyme disease-related myocarditis is generally favorable. Effective management often involves antibiotics to target the underlying infection and address cardiac complications. While the condition can cause temporary disruption to heart function, it rarely leads to long-term damage when appropriately treated (11, 12, 13).

In a recent study of heart valve infections, various bacterial species were identified, with Pseudomonas being the most prevalent, found in 70% of the analyzed samples. Roseateles followed closely at 60%, suggesting a significant presence in these infections. Acinetobacter and *Sphingomonas* were each present in 40% of cases, indicating a noteworthy role in valve-related pathologies. Enterococcus was found in 30% of the samples, which is consistent with its known association with endocarditis. Other bacterial species, though less common, were also identified, including *Reyranella, Sphingobium,* and *Streptococcus,* each contributing to 20% of the infections. *Agrobacterium* and *Ralstonia* were less frequent, detected in 20% and 10% of cases, respectively. Bacillus, another less common pathogen, was also found in 10% of the studied heart valves. This diverse bacterial presence underscores the complexity of infections in heart valve pathology and the need for broad-spectrum diagnostic approaches (14).

Infective endocarditis (IE), a bacterial infection affecting the heart or blood vessels, impacts between 40,000 and 50,000 individuals annually in the United States, with a 1-year mortality rate averaging 30%. People who inject drugs (PWID), typically younger, face a higher risk of developing IE due to the introduction of bacteria into the bloodstream. Recent data indicates that the

number of IE cases among younger individuals and PWID has risen, likely linked to the on-going opioid crisis. A study published in the *Journal of Internal Medicine* shows that the risk of death from IE among US residents aged 15–44 has doubled over the past two decades. Furthermore, nearly 20% of young people who succumb to IE are PWID (15).

CONCLUSION

The evolving landscape of cardiovascular infections underscores the critical need for accurate and timely microbiological identification in managing these complex conditions. The growing prevalence of microbial pathogens, ranging from bacteria to viruses and parasites, has significantly contributed to the burden of heart-related diseases globally. Infections such as endocarditis, myocarditis, and pericarditis, often caused by both common and rare pathogens, can severely impact cardiac function, leading to devastating outcomes if left untreated. As we have explored through various case studies, the early detection and targeted treatment of these infections can greatly improve patient prognosis and reduce long-term complications. However, the challenges in diagnosing these infections, especially in cases of silent or atypical symptoms, emphasize the necessity for heightened awareness and advanced diagnostic methods. Moving forward, clinical practices must prioritize the integration of microbiological tools into cardiovascular care to ensure more effective prevention, management, and treatment of these infections. In light of the ongoing global health concerns, interdisciplinary collaboration and continuous research are essential to tackle the rising incidence of cardiac infections and to develop more robust therapeutic strategies, ultimately safeguarding heart health worldwide.

Declaration by Authors

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