Emerging Biomarkers for Early Detection of Silent Coronary Artery Disease: Focus on Non-Invasive Imaging Techniques

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Introduction

Coronary artery disease remains a leading cause of mortality and morbidity worldwide. Silent coronary artery disease, characterized by the absence of overt symptoms, presents a unique challenge for early detection and intervention. Non-invasive imaging techniques have shown great promise in identifying subtle changes in the cardiovascular system before the onset of clinical symptoms. This review article aims to provide an overview of emerging biomarkers used in non-invasive imaging techniques for the early detection of silent coronary artery disease. We discuss various imaging modalities, such as coronary computed tomography angiography, cardiac magnetic resonance imaging, and positron emission tomography, highlighting their potential to uncover early signs of CAD. Furthermore, we explore the role of novel biomarkers, including endothelial dysfunction markers, circulating microRNAs, and plaque-specific molecular imaging agents. By focusing on these advancements, we emphasize the importance of early detection and risk stratification in mitigating the burden of silent CAD [1-3].

Coronary artery disease is a multifactorial cardiovascular disorder characterized by the progressive accumulation of atherosclerotic plaques in the coronary arteries. Silent coronary artery disease, often referred to as silent ischemia, occurs in individuals who lack the typical symptoms associated with myocardial ischemia, such as chest pain or discomfort. Despite its asymptomatic nature, silent CAD can lead to severe complications, including myocardial infarction and sudden cardiac death. Early detection and risk stratification are critical to prevent adverse outcomes in these patients.

Description

Non-invasive imaging techniques have revolutionized the field of cardiovascular medicine by enabling the visualization of coronary anatomy, myocardial perfusion, and tissue characteristics without the need for invasive procedures. This review focuses on emerging biomarkers employed in non-invasive imaging techniques for the early detection of silent CAD, with an emphasis on coronary computed tomography angiography, cardiac magnetic resonance imaging, and positron emission tomography. CCTA is a widely utilized non-invasive imaging technique that provides high-resolution images of the coronary arteries. It enables the visualization of coronary artery stenosis, plaque burden, and plaque composition.

Recent advancements in CCTA technology, such as improved spatial resolution and contrast agents, have enhanced its ability to detect early stages of CAD. CMR offers a comprehensive assessment of cardiac structure, function, and perfusion. Techniques such as late gadolinium enhancement imaging can identify myocardial scar tissue, while T1 and T2 mapping provide insights into myocardial tissue characteristics. CMR can also evaluate coronary blood flow and endothelial function using techniques like adenosine stress perfusion imaging. PET imaging allows for quantitative assessment of myocardial blood flow and metabolism. Emerging Biomarkers for Silent CAD Detection [4,5].

Endothelial dysfunction is an early event in atherosclerosis and can be assessed using non-invasive imaging techniques. Flow-mediated dilation measured by ultrasound and reactive hyperemia-peripheral arterial tonometry are indicators of endothelial function. Impaired FMD and RH-PAT responses have been linked to silent CAD, serving as early warning signs. MicroRNAs are small non-coding RNAs that regulate gene expression. Altered expression of specific circulating miRNAs has been associated with CAD progression. Non-invasive techniques such as quantitative polymerase chain reaction and next-generation sequencing can identify CAD-related miRNA signatures in blood, offering a minimally invasive approach for early CAD detection.

Molecular imaging agents targeting specific components of atherosclerotic plaques, such as macrophages and calcifications, hold promise for detecting vulnerable plaques. Near-infrared fluorescence imaging and PET imaging with plaque-specific tracers can visualize molecular processes implicated in plaque rupture. Early detection of silent CAD through non-invasive imaging and biomarkers is crucial for risk stratification and timely intervention. Integrating multiple imaging modalities and biomarkers may enhance diagnostic accuracy and improve patient outcomes. However, challenges remain, including standardization of imaging protocols, validation of novel biomarkers, and translation into clinical practice.

Conclusion

In conclusion, non-invasive imaging techniques coupled with emerging biomarkers offer unprecedented opportunities for the early detection of silent coronary artery disease. By identifying subtle changes in the cardiovascular system, these tools enable clinicians to intervene before the onset of clinical symptoms, ultimately reducing the burden of CAD-related morbidity and mortality.

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