

REVIEW ARTICLE

Current Perspectives on Cardiovascular Disease: Epidemiology, Prevention, and Therapeutic Advances

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Abstract:

Cardiovascular disease (CVD) continues to represent the leading cause of mortality worldwide, contributing to over 17.9 million deaths annually (1,2). Despite significant advances in diagnostics, therapeutics, and public health strategies, the global burden of CVD is on the rise, particularly in low- and middle-income countries (LMICs) (3). This comprehensive review explores the epidemiology, pathophysiology, clinical presentations, risk factors, and management strategies of CVD, highlighting contemporary and emerging therapeutic interventions. We also delve into the role of precision medicine, digital health, and future directions to mitigate the global cardiovascular burden. A multi-tiered, integrative approach spanning primordial, primary, and secondary prevention is essential for improving cardiovascular health outcomes globally.

Keywords: *Cardiovascular disease; atherosclerosis; risk factors; prevention; management; emerging therapies; precision medicine*

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1. Introduction

Cardiovascular disease (CVD) encompasses a broad spectrum of disorders affecting the heart and vasculature, including coronary artery disease (CAD), cerebrovascular disease, peripheral arterial disease (PAD), rheumatic heart disease, congenital heart disease, and heart failure (1,2). Globally, CVD is the leading cause of mortality, accounting for over 17.9 million deaths annually (2,3). The prevalence of CVD is increasing in both developed and developing countries, reflecting a complex interplay of genetic, environmental, and lifestyle factors (4,5). Risk factors such as hypertension, dyslipidemia, diabetes mellitus, smoking, obesity, sedentary lifestyle, and unhealthy diet contribute significantly to disease burden (6,7). Additionally, psychosocial stress and socioeconomic disparities amplify susceptibility and influence clinical outcomes (5,8). Urbanization and modernization have led to lifestyle changes, including reduced physical activity and increased consumption of processed foods, which are associated with higher rates of obesity, metabolic syndrome, and insulin resistance (6,7). Genetic predisposition also plays a critical role, with family history and specific gene variants affecting lipid metabolism, inflammatory responses, and coagulation pathways, thereby modulating individual CVD risk (9,10). Understanding gene-environment interactions is essential for personalized prevention strategies (10,11). CVD encompasses structural and functional changes in the heart and vasculature. Endothelial dysfunction, arterial stiffening, inflammation, and atherosclerotic plaque formation are fundamental pathophysiological processes (6,12). The progression from early endothelial injury to plaque rupture underlies most acute cardiovascular events, such as myocardial infarction and ischemic stroke (7,9). Microvascular dysfunction and thrombosis further complicate the clinical course (12,13).

The epidemiology of CVD demonstrates significant geographic and demographic variation. Low- and middle-income countries (LMICs) bear a disproportionate burden, with limited healthcare infrastructure, delayed diagnosis, and restricted access to therapies contributing to poor outcomes (3,5,8). In India, for instance, CVD accounts for more than a quarter of all deaths, highlighting the urgent need for effective prevention and management strategies (4,5). Conversely, high-income countries have observed reductions in CVD mortality due to advances in preventive care, pharmacotherapy, and interventional cardiology (3,7,14). Socioeconomic determinants, including income, education, occupation, and health literacy, influence risk factor prevalence, access to care, and adherence to therapeutic interventions (5,8). Public health initiatives, such as population-based screening, lifestyle modification programs, tobacco control policies, and health education campaigns, are critical components of effective CVD management (10,11). Integrating community-level interventions with individual clinical care can enhance outcomes and reduce health disparities (6,11,12). The clinical manifestations of CVD are diverse, ranging from asymptomatic atherosclerosis to acute coronary syndromes, stroke, heart failure, and sudden cardiac death (1,2,15). Early recognition of risk factors and subclinical disease is essential for timely intervention. Diagnostic strategies, including electrocardiography, echocardiography, biomarker assessment, and advanced imaging, facilitate early detection, risk stratification, and treatment planning (14,15). Given the complex interplay of biological, behavioral, environmental, and social factors, an integrated approach to prevention and management is required. This approach encompasses primordial prevention to avert risk factor development, primary prevention to manage existing risk factors, and secondary prevention to prevent recurrent events in patients with established disease (10,11,16). Precision medicine, leveraging genetic profiling, biomarkers, and advanced imaging, allows for individualized risk assessment and tailored therapeutic interventions (17).

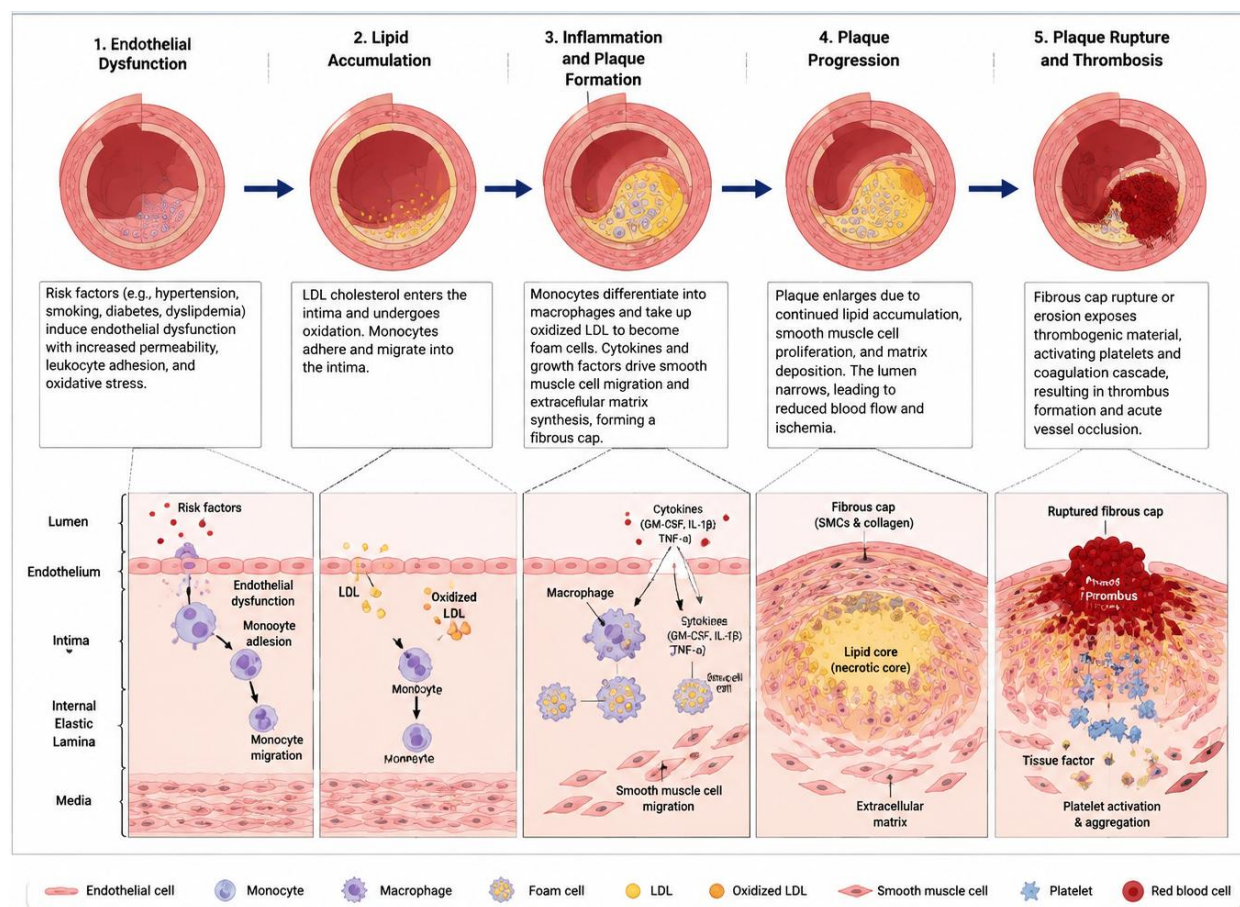


Figure 1. Pathophysiology of atherosclerosis: from endothelial dysfunction to plaque rupture and thrombosis

2. Epidemiology and Global Burden

The World Health Organization reports that CVD caused an estimated 17.9 million deaths in 2019, with 85% attributable to myocardial infarction and stroke (2,3). Age-standardized mortality rates have declined in high-income countries due to improved medical interventions and preventive measures (3,7), yet they continue to rise in LMICs. India illustrates this trend, facing a dual burden of communicable and non-communicable diseases (4,5). Socioeconomic disparities, limited healthcare infrastructure, and delayed diagnosis exacerbate outcomes (6). The economic impact of CVD is substantial, encompassing direct healthcare costs, hospitalizations, pharmaceuticals, and indirect costs such as loss of productivity and premature mortality (5,8). Globally, investments in preventive strategies have been shown to be cost-effective and yield long-term health benefits (10).

3. Pathophysiology

Atherosclerosis is the hallmark pathology underlying most cardiovascular events (6,7). It is a chronic, progressive inflammatory disease characterized by endothelial injury, lipid accumulation, leukocyte infiltration, smooth muscle proliferation, and extracellular matrix remodeling (6,7). Plaque formation begins with endothelial dysfunction, often triggered by oxidative stress, hypertension, smoking, and hyperlipidemia (6). LDL cholesterol particles infiltrate the intima, undergo oxidation, and incite an inflammatory cascade involving macrophages, T lymphocytes, and cytokines (7,8). Advanced plaques may develop necrotic cores and fibrous caps that are prone to rupture, resulting in thrombosis

and acute vascular occlusion (7,9). Other pathophysiologic mechanisms include microvascular dysfunction, arterial stiffening, and prothrombotic states (6,7,9). Systemic inflammation, insulin resistance, and genetic variants in lipid metabolism, coagulation pathways, and inflammatory mediators modulate disease progression (6,7). Sex-specific differences, hormonal influences, and epigenetic modifications further contribute to individual variability in disease onset and severity (6).

4. Risk Factors

CVD risk factors are divided into modifiable and non-modifiable categories (10,11). Non-modifiable factors include age, sex, ethnicity, and genetic predisposition (10). Modifiable factors encompass hypertension, dyslipidemia, diabetes mellitus, obesity, physical inactivity, unhealthy diet, smoking, and psychosocial stress (11,12). The clustering of these factors exponentially increases cardiovascular risk (11). Emerging risk factors include chronic kidney disease, inflammatory disorders, autoimmune diseases, sleep disorders, and environmental exposures such as air pollution (10,12). Socioeconomic determinants, health literacy, and access to care also significantly influence CVD prevalence and outcomes (5,6). Risk assessment tools, including the Framingham Risk Score, ASCVD pooled cohort equations, and QRISK3, facilitate individualized risk stratification and guide preventive strategies (11,12). Integration of imaging, biomarkers, and clinical data enhances prognostication and informs therapeutic decision-making (14).

5. Management and Treatment

Management strategies encompass lifestyle interventions, pharmacologic therapies, and invasive procedures tailored to individual risk profiles and disease severity (11,12,14,15).

5.1 Lifestyle Interventions

Lifestyle modification remains the cornerstone of both primary and secondary prevention (11). Heart-healthy diets, including Mediterranean, DASH, or plant-based diets, reduce LDL cholesterol and improve endothelial function (10,12). Regular physical activity, at least 150 minutes of moderate-intensity exercise weekly, improves cardiovascular fitness and insulin sensitivity (11). Smoking cessation, stress management, and weight control significantly reduce overall CVD risk (11,12).

5.2 Pharmacologic Therapy

Pharmacologic therapy targets specific risk factors and established disease (11,12,14). Antiplatelet therapy (aspirin, P2Y₁₂ inhibitors) prevents thrombosis in patients with prior events (11,12). Statins, ezetimibe, and PCSK9 inhibitors lower LDL cholesterol and reduce plaque progression (12,16). Antihypertensive therapy—including ACE inhibitors, ARBs, beta-blockers, calcium channel blockers, and diuretics—targets optimal blood pressure control (13,14). Glycemic management with metformin, SGLT2 inhibitors, GLP-1 receptor agonists, and insulin therapy reduces both microvascular and macrovascular complications in diabetes (14,15). Heart failure management includes RAAS inhibitors, beta-blockers, mineralocorticoid receptor antagonists, SGLT2 inhibitors, and device therapy such as ICDs or CRT when indicated (15).

5.3 Interventional and Surgical Therapy

Percutaneous coronary intervention (PCI) with stenting and coronary artery bypass grafting (CABG) are critical in patients with obstructive coronary disease (14,15). Structural interventions, including transcatheter valve replacement, are increasingly utilized for valvular heart disease (15). Multidisciplinary heart teams optimize procedural outcomes and long-term survival (14).

5.4 Prevention Strategies

Preventive strategies encompass primordial, primary, and secondary prevention (11,12). Primordial prevention focuses on preventing the development of risk factors through early education, lifestyle promotion, and policy measures (10). Primary prevention targets individuals with risk factors to prevent incident CVD (11). Secondary

prevention aims to reduce recurrent events in patients with established disease (12,16). Population-level interventions, including tobacco control, food policy, environmental modifications, and urban planning, complement individual-level strategies (10,11). Digital health platforms and patient engagement tools improve adherence and self-management, enhancing prevention efficacy (17).

5.5 Emerging Therapies and Precision Medicine

Emerging therapies target novel pathways in atherosclerosis, inflammation, and thrombosis (16,17). Anti-inflammatory agents such as colchicine and canakinumab have shown promise in reducing cardiovascular events (16). RNA-based therapies, gene editing, and regenerative medicine approaches may further modulate disease progression (17). Precision medicine integrates genetic profiling, biomarkers, and advanced imaging to tailor therapies to individual patients, optimizing outcomes (17).

6. Discussion

Cardiovascular disease (CVD) encompasses a broad spectrum of disorders affecting the heart and vasculature, including coronary artery disease (CAD), cerebrovascular disease, peripheral arterial disease (PAD), rheumatic heart disease, congenital heart disease, and heart failure (1,2). Digital health technologies, including wearable devices, remote monitoring, and mobile applications, provide continuous data on heart rate, rhythm, activity, and blood pressure (17). AI-driven analytics can identify early deviations from normal, enabling proactive interventions. Predictive modeling supports clinical decision-making, triage, and population health management, potentially transforming cardiovascular care (17). Addressing social determinants of health—such as income, education, occupation, and access to care—is critical to reducing disparities in CVD outcomes (5,6). Global health initiatives targeting prevention, education, and capacity building in LMICs are essential for curbing the rising CVD burden (3,5,6). Policy interventions, public-private partnerships, and community-based programs play pivotal roles in implementing sustainable cardiovascular health strategies (5,6). Future research priorities include exploring the molecular underpinnings of atherosclerosis, inflammation, and thrombosis to identify new therapeutic targets (6,7,16). Integration of genomics, metabolomics, and proteomics will refine risk stratification and enable personalized therapy (17). Advancements in telemedicine, AI, and wearable technology will facilitate early detection, remote management, and real-time monitoring (17). Ensuring equitable access to innovative therapies and preventive services remains essential for global cardiovascular health improvement (5,6).

7. Conclusion

Cardiovascular disease remains the predominant cause of morbidity and mortality worldwide (1,2,3). Comprehensive management requires a multidisciplinary approach encompassing prevention, early diagnosis, risk factor modification, pharmacotherapy, interventional procedures, and emerging therapeutic strategies (11,12,14,15,16). Integrating precision medicine, digital health, and population-level interventions promises to transform CVD care (17). Addressing social determinants and promoting equitable access to care are critical to reducing the global cardiovascular burden (5,6).

Conflict of Interest: The authors declare no conflicts of interest.

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