Treatments and Prevention of CVDs by Taking an Insight into the Mechanism of Cardiovascular Aging

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Abstract. In an era of rapid technological advancement, a notable and convincing demographic trend is emerging: a significant increase in the elderly population. This demographic shift is represented by numerous factors, including enhanced healthcare, medical breakthroughs, and improved living standard conditions. This transformation brings numerous concerns for the health and well-being of the elderly. This concern is particularly pronounced when considering the impact of cardiovascular aging, a critical facet of their overall health that carries substantial implications for governments and healthcare systems worldwide. However, people's knowledge of these diseases and our ability to control epidemics is still limited. Cardiovascular aging brings many changes to our lives and poses high risks for the elderly. This report aims to analyze cardiovascular changes and combine existing medical methods to make efficient suggestions. To address the challenges posed by the aging population to cardiovascular disease, it is important to cultivate a comprehensive approach that includes risk factor management, lifestyle interventions, and advanced therapies.

Keywords: Cardiovascular aging, impacts, treatments.

1. Introduction

The phenomenon of global population aging is a matter of widespread concern that spans across the entire world. This demographic shift has profound implications for various aspects of society and paying attention to the elderly body has become an increasingly important issue in today's world. As individuals progress through the aging process, their bodies undergo significant changes. Among the prominent global causes of mortality, cardiovascular disease holds a dangerous position, with advancing age being a key factor in its development and prevalence. The elderly faced higher risks of cardiovascular disease compared with the younger. In the context of individuals aged below 45, the occurrence of cardiovascular disease is notably limited, constituting a mere 0.010 incident rate (26 cases out of 2712). Similarly, the mortality rate associated with this age group is remarkably low at 0.008 (21 cases out of 2712). In contrast, the dynamics shift significantly when examining those aged over 65, where the incident and mortality rate of cardiovascular disease surges to 0.060 (245 cases out of 4050) and 0.117 (474 cases out of 4050) respectively [1]. The elderly population encounters a significant and elevated risk of developing cardiovascular disease. This health issue encompasses various conditions that impact the heart and circulatory system. This increased vulnerability is rooted in a complex interplay of physiological changes, lifestyle factors, and accumulated effects over time.

Cardiovascular aging represents a progressive phenomenon characterized by the gradual decline in the cardiovascular system's structural integrity and functional efficiency. This process spans an individual's entire lifespan, starting early in life and representing most noticeably as one advances in age. Changes in the structure and function of the cardiovascular system are an inherent outcome of the aging process and frequently coincide with a heightened susceptibility to cardiovascular diseases (CVDs) and associated health concerns as individuals age.

Elderly individuals are at an elevated risk of heart disease owing to the higher incidence of age-related conditions like diabetes, hypertension, and the accumulation of cholesterol. More complex are age-related changes in human heart structure and function, including fibrosis, left ventricular hypertrophy, changes in the function of left ventricular diastolic, and reduced left ventricular contractile ability [2].

Aging is the foremost contributor to a higher risk of cardiovascular disease. Nevertheless, strategies aimed at addressing the aging process itself or prolonging a healthy lifespan currently lack widely accepted treatment methods for cardiovascular disease. However, a shift is occurring, whereby efforts to resist harmful lifestyle habits linked to aging and cardiovascular issues are gradually becoming integrated into the established care approach. This includes reversing unhealthy behaviors like smoking, sedentary habits, and specific dietary patterns [3]. While pharmacological and surgical interventions exist, they primarily focus on reducing symptoms rather than addressing the underlying causes [4]. The emphasis remains more on symptom management rather than comprehensive intervention. Cardiovascular disease causes many continuous diseases and hardly gets comprehensive treatments. So it is important to explore the effect of cardiovascular disease and its treatment method on the physical health of the elderly. This research is on the changes caused by CVD in heart failure, myocardial hypertrophy, and arteriosclerosis as examples to analyze the corresponding formation mechanism of its harm to the human body, combined with the current treatment. It provides feasible suggestions for future treatment and prevention.

2. Effects of Cardiovascular Aging on the Human Body

2.1. Cardiovascular Aging Leads to Heart Failure

CVDs stand as the primary contributor to worldwide mortality. In 2019, around 17.9 million people succumbed to CVDs accounting for 32% of the total worldwide deaths [5]. Among these fatalities, a significant 85% were attributed to heart attacks and strokes [5]. Heart failure (HF) is one type of CVD associated with cardiovascular aging that poses high risks to elderly people. HF represents a persistent and progressive chronic condition that deteriorates as time unfolds. This ailment has a far-reaching impact, affecting approximately 64 million individuals across the globe [6].

Heart failure, known as cardiac insufficiency or congestive heart failure, refers to the impaired function of the heart's systolic and diastolic functions. This impairment hinders the heart's ability to effectively pump the blood volume returning from the veins, causing blood to accumulate within the venous system. This, in turn, leads to sluggish blood flow in the veins and insufficient blood supply throughout the arterial system, giving rise to a syndrome known as cardiac circulation disorder. In this context, heart failure isn't a standalone disease entity; rather, it serves as the culmination of a cascade of events within the spectrum of heart ailments. The initial phase often involves left heart failure, which acts as a precursor to the broader syndrome.

2.2. Cardiovascular Aging Leads to Myocardial Hypertrophy

The cardiac muscle, also known as the myocardium, which situated at the central layer within the heart wall and has the essential duty of contracting and propelling blood through the heart's chambers [7]. Comprising countless specialized cells, these heart muscle cells operate collectively to ensure the heart's effective pumping action. These specialized cells are abundantly present across the walls of all four chambers, collectively contributing to the heart's remarkable function [7]. As aging, fully matured adult cardiomyocytes (CM), the fundamental building blocks of the heart's tissue, reach a state of terminal differentiation where they cease to undergo cell division. Unlike many other cell types, these CMs lose the capacity to replicate and draw a parallel with neurons and they are assumed to persist throughout an individual's lifespan [8]. This resemblance to the non-dividing nature of neurons has led to the perception that CMs, like neurons, have enduring longevity [8]. The biological perspective is the concept that the heart in response to sustained strain or injuries that may be widespread or localized triggers an adaptive mechanism [8]. In such a situation, CMs will increase in size, a phenomenon term called hypertrophy [8].

Almost all heart failure starts from the Left Ventricle (LV). Left ventricular hypertrophy involves the notable thickening of the wall on the left side of the heart, which happens to be the primary powerhouse responsible for pumping blood. This adaptive alteration in heart structure is often

prompted by enduring conditions or factors that impose stress upon the heart muscle. In the presence of left ventricular hypertrophy, the muscular wall becomes denser, which can potentially lead to an associated stiffening effect [9]. This triggers a dramatic increase in the heart's blood pressure levels and creates a bigger obstacle when transporting blood [9]. Consequently, the heart's intrinsic ability to effectively propel blood throughout the circulatory system encounters difficulties.

Advanced imaging techniques give an essential judgment range known as the ejection fraction, a pivotal indicator for categorizing heart failure types [10]. If the left ventricle of the heart is responsible for pumping 40% or less of the blood volume within a single cycle, the likelihood of heart failure increases substantially [10]. Conversely, an average ejection fraction ranges between 50% and 70%, reflecting the typical pumping efficiency of a healthy heart [10]. Cardiac hypertrophy progresses as people get older, the heart's chambers may become dilated, and its walls may lose their elasticity, further compromising the heart's ability to pump blood efficiently. Additionally, the altered structure of the heart can disrupt the normal electrical pathways, potentially leading to arrhythmias and further complicating cardiovascular function.

2.3. Impacts of Cardiovascular Aging on Artery Wall

The heart artery has a cross-sectional view that reveals its distinct composition, comprised of three distinct layers: the inner, middle, and outer layers. Positioned between the circulating blood and the inner layer is a single layer of endothelium [11]. This specialized endothelial layer serves to create a smooth inner surface within the blood vessel to reduce friction as blood flows [11]. The arterial architecture varies across different regions, with arteries proximate to the heart displaying a prominent presence of elastic fibers within the middle layer. In contrast, other segments feature a higher proportion of smooth muscle and reduced elastic tissue within the middle layer [11].

Artery stiffening is characterized by changes in both the structural configuration and microarchitecture of the vessel wall. As individuals progress in age, the levels of collagen content within the arterial walls decline annually, accompanied by a reduction in the integrity of elastin due to elastin fractures and diminished elastin content [12]. Moreover, the covalent cross-linking of collagen also undergoes changes as part of this age-related transformation [12]. As individuals age, the natural process of enzymatic degradation affects elastin, facilitated by the ongoing expression of proteases within healthy tissues [13]. This degradation of elastin can potentially lead to the deterioration of elastic fiber function, and in turn, give rise to the liberation of bioactive elastin peptides called elastin fragments [13]. These elastin fragments, while released during this process, can subsequently contribute to the intricate chain of events. Moreover, an irregular elevation in elastase expression and subsequent proteolytic activity aimed at elastic fibers can be triggered by the presence of elastin [13]. These kinds of biological events hold together and can trigger artery stiffening (atherosclerosis). This process starts within the inner membrane of the artery (endothelium), primarily composed of fatty elements, cholesterol, cellular remnants, calcium, and fibrin deposits [14]. Subsequently, it entails the progressive breakdown and calcification of the arterial middle layer [14]. As this buildup accumulates within the arteries, it leads to an increase in the thickness and rigidity of the arterial walls. Consequently, this change diminishes the flow of blood and restricts the delivery of oxygen to crucial bodily organs and extremities.

2.4. Modern Biotechnologies Reveal Epigenetic Mechanisms of Cardiovascular Aging

The development of CVDs is influenced by intricate interplays between genetics, epigenetics, and the environment. In the epigenetic model, DNA methylation is of great concern. 5-methylcytosine is one of the pyrimidine bases of many animals and plant DNA deoxynucleotides. Irregular DNA methylation disrupts the transcription and expression of crucial regulatory genes, triggering atherosclerotic cell characteristics [15].

Accumulating evidence underscores the significant contribution of DNA methylation in the intricate orchestration of endothelial cells (EC), vascular smooth muscle cells (VSMC), fibroblasts, and macrophages' functionalities [16]. This epigenetic mechanism plays an important role not only

in the individual functions of these cell types but also in the coordination of their interactions within the vascular. Moreover, DNA methylation's involvement extends beyond cellular function, including critical processes associated with vascular aging and a spectrum of related diseases. Within this dynamic context, DNA methylation acts as a regulatory switch, influencing gene expression patterns that steer the behavior of ECs, VSMCs, fibroblasts, and macrophages [16]. These distinct cellular entities collectively shape the vascular microenvironment, playing roles in processes such as angiogenesis, vascular tone regulation, extracellular matrix maintenance, and immune responses [16].

The methylation status of hundreds of CpG sites has been used to measure the rate of aging in humans. An analogous Epigenome-Wide Association Study (EWAS) conducted within the context of acute coronary syndrome yielded compelling findings. This investigation published distinctive blood methylation patterns across 47 CpG sites residing within genes intricately linked to atherogenic signaling cascades and the orchestration of immune responses [17]. These identified CpG sites offer a valuable glimpse into the epigenetic landscape underlying acute coronary syndrome, shedding light on the molecular intricacies that contribute to the disease's pathogenesis [17].

3. The Treatment and Analysis for Cardiovascular Aging

When people were diagnosed the heart failure, the treatments for every patient was different according to their symptom. Heart failure typically occurs as a gradual and chronic condition with symptoms emerging progressively. Initially, these symptoms may only become noticeable during periods of vigorous activities or even no symptoms at the early stage. Moreover, the symptoms of heart failure can progress from mild to severe. The primary indicators encompass sensations such as breathlessness, a rapid or irregular pulse, and a sense of breathlessness during physical exertion or after lying down [18]. Symptoms are typically accompanied by observable clinical indicators, including peripheral edema and jugular vein dilation, among others. [18].

3.1. Diuretics

Diuretics can reduce signs of fluid retention by increasing urine volume/speed and urinary sodium excretion, and they mainly contain five classes: thiazide, potassium-conserving diuretics, loop, osmotic, and carbonic anhydrase inhibitors [19]. They inhibit the Na K-2Cl co-transporter protein in the thick ascending limb of the Henry ring [20]. The diuretic response is related to a urine agent's capacity to prompt sodium excretion or diuresis once administered. Diuretic resistance leads to decreased urinary sodium excretion [21]. This resistance curtails the potential to attain a standard blood volume through diuretic usage. It will effectively inhibit sodium reabsorption, and reducing water reabsorption is the key factor accompanied [21]. When normal blood volume is achieved, the degree of volume overload and diuretic response will determine the success of treatment. For the time, diuretics are safe to eat, and their side effects include increased urination and sodium loss. However, if 4overused diuretics, it will lower blood pressure and impair kidney function and exercise tolerance, as well as accompanying headaches, muscle cramps, and gout.

3.2. ACE Inhibitors

ACE inhibitors are a type of drug that can dilate the heart and cardiovascular system. This increases the pumping capacity of the atrial ventricles to increase blood flow and lower blood pressure. It helps reduce the workload of the heart [22]. Reducing the left ventricle improves symptoms of heart failure through vasodilation, thereby increasing cardiac output and reducing filling pressure in the left and right heart to improve pulmonary and systemic venous congestion [22]. The side effects of ACE inhibitors are less compared with diuretics. It simply increases potassium levels in the blood (hyperkalemia), and loss of taste, and may cause local swelling of tissues (angioedema) in rare cases.

3.3. Plant-based Remedies

To combat and prevent cardiovascular disease, a significant number of individuals turn to traditional plant-based remedies which are rich in phytochemicals beyond conventional pharmaceuticals. These natural compounds have demonstrated their ability to against various cardiovascular components, including macrophages, monocytes, cardiomyocytes, vascular smooth muscle cells, and endothelial cells, thus reducing the potential for damage [23]. A notable example is Scutellaria baicalensis, an herb belonging to the Liliaceae family [24]. Studies have revealed that a specific compound found in Scutellaria baicalensis is known as TFSB. It holds the potential to reduce CVDs by hindering apoptosis, regulating oxidative stress, actively participating in anti-inflammatory processes, averting myocardial fibrosis, curbing myocardial hypertrophy, and maintaining proper blood vessel function [24]. However, the therapy period for using plant-based remedies is much longer and less efficient compared with other therapies. Unlike some conventional therapies that may offer quick and targeted relief, plant-based remedies often work gradually and rely on the body's natural processes to restore balance and promote healing. This gradual approach can require a longer treatment timeline to achieve the desired results. Moreover, plant-based therapies often emphasize preventive care, which may not produce immediate symptomatic relief but can have long-term benefits for overall well-being. Patients opting for plant-based therapies may need to invest more time in adopting lifestyle changes, such as dietary adjustments, regular exercise, and stress management.

4. Suggestions

In the context of present-day society, newly developed medicines and treatments have been introduced to address cardiovascular disease. These advancements represent remarkable progress in medical science and technology, offering ways to manage and reduce the symptoms associated with cardiovascular conditions. However, it's crucial to underscore that while these pharmaceutical interventions and therapeutic approaches have proven effective in minimizing the outward manifestations of cardiovascular disease. They typically fall completely eradicating the root causes or reversing the underlying physiological processes responsible for the ailment. The medications and treatments currently available primarily focus on mitigating symptoms for a limited duration. However, if individuals discontinue the use of these medications, their quality of life might not remain as seamless. This will give a financial and spiritual burden to patients.

Although cardiovascular aging poses many hazards, public awareness about CVD is weak. Elderly individuals tend to perceive a lower risk of CVDs than the actual level of dangerous they face. They do not feel any seriousness and urgency, so they do not seek a medical diagnosis immediately. As a result, they die of treatable diseases. In fact, most CVDs can be prevented due to certain circumstances, such as increased publicity and rapid detection of the makers. Indeed, having a healthy lifestyle can have a remarkable influence on reducing the risk of various diseases, including cardiovascular ailments. In addition to medical interventions, cultivating positive habits and making thoughtful choices can significantly improve overall well-being and reduce the vulnerabilities often associated with aging.

5. Conclusion

In conclusion, cardiovascular aging is a complex and complicated process that significantly impacts the overall health and well-being of individuals as they grow older. As aging, the cardiovascular system undergoes a series of changes, including structural alterations in the heart and blood vessels, functional declines in cardiac performance, and an increased risk of developing various CVDs.

It is essential to recognize that aging does not necessarily equate to an inevitable decline in cardiovascular health. With advancements in medical research and a greater understanding of the mechanisms underlying cardiovascular aging, there are many preventive measures and treatments

available to reduce the effects of aging on the heart and blood vessels. Lifestyle modifications can also improve cardiovascular functions as individuals age, such as regular physical activity, a balanced diet, and inhibiting smoking.

Research on cardiovascular aging has made significant progress in recent years. However, there are several gaps that remain, and future studies could address these areas to further understanding and improve clinical outcomes. While lifestyle modifications and medications can help manage cardiovascular aging, there is a need for innovative therapies that can slow down or reverse the aging-related changes in the cardiovascular system. They should be more efficient and have fewer side effects on human bodies. Research should explore novel treatment modalities, including regenerative medicine and gene therapy. Addressing these research gaps in cardiovascular aging will contribute to a deeper understanding of the processes involved and lead to more targeted interventions and treatments.

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