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Inflammaging As A Central Driver Of Age-Related Atherosclerosis: Mechanisms, Lifestyle Determinants, And Therapeutic Perspectives

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Abstract

Aging is a key risk factor for atherosclerosis & cardiac diseases, subject to continued structural & physiological fluctuations in the walls of arteries. With growing age, vascular ossification, endothelial dysfunction & lipid accumulation form a pro-inflammatory environment that is more augmented by ongoing, substandard sensitivity known as inflammaging. This review analyzes the biological & curative links between aging, atherosclerosis & inflammaging, traumatized causal molecular mechanisms & their implications for cardiovascular health. Pivotal pathogenic processes under discussion include immunological dysregulation, oxidative stress, cellular senescence, and altered lipid metabolism, all of which contribute to the initiation and progression of atherosclerotic lesions. This review analyzes impact of routine factors—such as regime, bodily activity, smoking, use of alcohol, sleep patterns, and social anxiety—on inflammatory problem and vascular aging. Emerging studies on restorative approaches directing inflammaging with anti-inflammatory mediators, digestive tract microbiota variation, caloric constraint, and Seno-lytic interpositions, is also studied. Studying the interaction between age-linked irritation, life determining factors & vascular pathology may offer opportunities for initial anticipation and tailored supervision of age-linked atherosclerosis, eventually refining cardiovascular consequences in the aged people.

Introduction

Aging is a biological phenomenon characterized by step by step cell based breakdown and physiological functional alterations. With progressing age, people demonstrate a

prominent surge in the risk of the cardiovascular illnesses, expressly atherosclerosis, which is a continuing, advanced disorder manifested by the accrual of plaque within walls of arteries (Lakatta & Levy, 2003).

With time, a number of Factors together with oxidative stress, endothelial disfunction, lipid accrual, and chronic swelling, sum up to root atherosclerosis. Due to diminished nitric oxide bioavailable and raised reactive oxygen (O2) species (ROS) generation, vascular endothelium turns out to be less capable of maintaining vascular tone & equipoise as people age (Donato et al., 2018; Iftikhar et al., 2021).

Besides, a chief aspect in the vascular variations carried on by aging is cellular anility. An inflammatory intermediary's situation, generally termed as "inflammation," is enabled by senescent endothelium & cells of smooth muscle and rushes the commencement of atherosclerotic plaque (Childs et al., 2015). Age-linked stiffness of arteries and diminished vascular tissue redeveloping size aggravate this more. (Ungvari et al., 2018).

In assumption, a number of interconnected processes, comprising oxidative strain, cellular waning & inflammation, upsurge exposure to atherosclerosis as individuals age. According to Donato et al. (2018), these conclusions suggest that directing on aging progressions may show fresh tactics to dodging cardiovascular ailment in the elderly (Bilal[a,b] et al., 2026).

Aging and Arterial Changes

Aging distresses hearth system with noticeable results in vessels functions. Mechanical alterations occur due to aging with continuing increased stiffness and hardening of arterial vessels walls, mainly due to extensive forming of collagen molecules & elastin deprivation that directly affects the circulatory system vessel capability of elasticity and heightened effect of toughness of arteries (Lakatta, 2015). The resulting rigorous arteries and compromised elasticity capability become the risk factors for advancements of atherosclerotic plaque formations that is a categorized by escalation of lipid buildup in arterial vessels (Grier, Kumar, & Herrmann, 2019). As person grows arterial changes occurs: that becomes the pivotal proof of aging related changes to vessels system, heart and escalation of atherosclerotic plaque formation (Sardar et al., 2026).

Pathogenesis of Atherosclerosis

The disease: Atherosclerosis instigates with dysfunction of endothelial membrane and causes formation of complex plaques in arteries. Endothelial cells constitutive component of blood vessels ends up malfunctioning due to age with extensive oxidative stress & extreme inflammation (Griendling & FitzGerald, 2014). The characteristic of this malfunction is altered vessel tone & affected permeability that results in increased influx of LDL-molecules (low density lipoproteins cholesterol molecules) in arterial vessel walls (Libby, 2013). This LDL pile up in addition to chronic inflammation encounters leads to formation of atherosclerotic plaques. These are formed of Inflammatory cells, lipid-cholesterol molecules & fibrous tissues leading to shrinking of arteries & hamper flow of blood in vessels. All these subpoenas are conclusive for outcoming interpositions leading to thwarting & management of Atherosclerosis in growing age population (Bilal et al., 2021).

The cardiovascular system is pointedly obstructed by aging, with chief significances for arterial health. People's arteries modification structurally & functionally as they age, levitating their risk of cardiovascular sicknesses. The two most central modifications are inspissation of the arterial walls & augmented arterial rigorousness, which equally affect vascular role and are connected to heart failure, ischemia occurrences &hypertension.

The accumulation of collagen & failure of the elastin in the artery wall, particularly in the medial layer, are II of the basic structural variations that damage arterial elasticity & form basis of the arterial toughness (Lakatta, 2015).

According to studies, lipid degeneration and arterial stiffness are linked to "atherosclerosis." Patchy intramural thickening of the subintima that encroaches on the arterial lumen is a characteristic of this process, which affects medium- and large-sized arteries. This process may have an impact on each arterial bed; the causes, therapies, and clinical consequences of atherosclerosis differ among vascular beds. The accumulation of lipid-rich foam cells in the artery's intimal layer causes the fatty stripe, the first obvious sign of atherosclerosis. The fatty streak eventually turns into a fibrous plaque, which is the telltale sign of advanced atherosclerosis (Bilal, 2021).

Significant quantities of lipid may eventually accumulate in the lesion; if this happens, the underlying artery may thrombose due to denudation of the endothelium or plaque rupture. Three main components make up atherosclerotic lesions. The first part is the cellular component, which is primarily made up of macrophages and smooth muscle cells. The extracellular lipid and connective tissue matrix make up the second element. The third element is intracellular lipid, which builds up inside macrophages and causes them to become foam cells.

Inflammatory stimuli, the following release of several cytokines, smooth muscle cell proliferation, connective tissue matrix formation, and the buildup of macrophages and lipids all contribute to the development of atherosclerotic lesions (Bilal et al., 2022).

Roles of inflammation, endothelial perturbation and lipids

Lipids, inflammation & endothelial disruption in the presence of an adverse serum lipid profile, endothelial cells' overexpression of adhesion protein molecules in anticipation of high flow rates is most likely what starts atherosclerosis. The influx of inflammatory cells, the release of cytokines, and the infiltration of fats into the plaque caused by atherosclerosis are subsequently "set up" by enhanced cellular adhesion and related endothelial dysfunction.

Slowly growing over time as a result of foam cell accumulation is the hallmark of atherosclerotic plaque evolution. Chronic stable angina may be brought on by the plaque's slow enlargement. However, myocardial infarction frequently happens in vessels that narrow in a pretty ordinary way. This implies that a large number of myocardial infarctions are caused by rapidly expanding plaques. The root cause of acute thrombotic blockage of the epicardial arteries in locations of atherosclerotic disease has been further investigated as a result of this observation (Ahmad et al., 2023).

The definitive fibrous coating is created by amplification of cells of smooth muscle and the development of intracellular matrix; slowly expanding plaques progressively concentrate lipid within foam cells. These plaques typically include persistent endothelial sheets that are resistant to abrupt disruption and the coagulation activation that goes along with it(Crowther, 2005).

Certain plaques expand significantly faster than would be expected from a simple accumulation of lipids and the expansion of the fibrous plaque's constituent parts. Both the "passive" expulsion of LDL from the bloodstream and the filtering of the red blood cell membranes formed during intraplaque bleeding are responsible for the buildup of cholesterol within such plaques. Plaque hemorrhage is probably caused by bleeding from brittle micro-vessels that multiply within the calcification itself, most likely in reactions to localized angiogenic stimuli. However, the mechanisms behind angiogenesis signaling and micro-vessel proliferation within the plaque are still poorly understood. Researchers identified that intraplaque hemorrhage from micro-vessels triggering macrophage activation and foam cell formation in carotid lesions (Bilal et al., 2021).

According to these authors, intraplaque microhemorrhage may trigger the deposition of platelets and erythrocytes, cause iron to be deposited, stimulate macrophages, and aid in the production of foam cells. The discovery that within plaque tiny vessels were a distinct indicator of plaque rupture has strengthened evidence for the role of revascularization in the pathophysiology of plaque formation. Experiments showing that antiangiogenic medication decreased the formation of atherosclerotic lesions in a

placebo-controlled trial in mice predisposed to atherosclerosis suggest the possible significance of angiogenesis in the progression of atherosclerosis. There are now planned or ongoing antiangiogenic therapy trials for people with atherosclerotic vascular disease. (Crowther, 2005).

These alterations cause systolic hypertension in elderly persons by decreasing vascular compliance and raising pulse wave velocity. Additionally, arterial stiffness increases the left ventricle's pressure burden and decreases coronary perfusion, making ischemic heart disease more likely (Grier, Kumar&Hermann,2019).

Age-related vascular smooth muscle cell (VSMC) proliferation, the extracellular matrix reconstruction, and poor-quality chronic inflammation all contribute to intimal & medial thickness of arteries (Donato et al., 2018). These alterations encourage arteriosclerosis, which is different from atherosclerosis but works in concert with it. Arteriosclerosis is a diffuse thickening and hardening of the artery walls.

Additionally, vascular aging is characterized by endothelial dysfunction. Vascular homeostasis is disrupted when endothelial cells age due to decreased nitric oxide (NO) accessibility, diminished vasodilatory function, and elevated oxidative stress (Ungvari et al., 2018). Because it promotes inflammation, increases vascular permeability, and facilitates leukocyte adhesion, this dysfunction is essential to early atherogenesis.

Furthermore, artery remodeling and atherogenic mechanisms are made worse by "inflammaging," a chronic low-grade inflammatory condition linked to aging (North & Sinclair, 2012). Reactive oxygen species, or ROS, and inflammatory cytokines are key players in the development of atherosclerosis because they cause lipid oxidation, endothelial damage, and smooth cells of muscles migration (Noor et al., 2024).

Age-related micro-angiopathic changes, like capillary fine-tuning & conceded auto-regulation, supplementary restricted oxygen carriage to tissues increase the risk of cardiovascular disease (Van Varik et al.,2012).

Amplified rigorousness, dysfunctional endothelial cells, vascular alteration and inflammation are some age-related arterial modifications that in conjunction create a biological background that boosts atherosclerotic & cardiovascular disease. Developed personalized treatments and anticipatory trials to decrease age-linked vascular risk need a thoughtful insight of these pathways (Bilal et al., 2024).

Age-linked failures in vascular health are mainly caused by molecular & cellular changes inside the artery wall, on top of the structural makeover. Epigenetic variations, including methylation of DNA & histone alteration are amongst the crucial age-linked changes that influence gene expression patterns connected to oxidative strain, inflammation & vascular cell death (Franceschi et al., 2018). Vascular deterioration is triggered by pro inflammatory pathways and suppressing supporting genes.

Damage of mitochondria is another main affect of this process. In vascular cells, especially endothelium & smooth muscle cells; aging influence mitochondrial biogenesis & function. Endothelial senescence & ability of vascular system to restore itself are aggravated by mitochondrial mutilation to DNA and decreased ATP synthesis (Chistiakov et al., 2014). Chronic inflammation is also brought on by damaged mitochondria's increased production of mitochondrial ROS, which in turn activates redox-sensitive gene transcription factors like NF-κB.

Along with ROS and inflammatory processes, prolonged high blood sugar and oxidative metabolism results in advanced products of glycation (AGEs) to build up in the artery wall as people age. According to Semba et al. (2009), AGEs cause collagen and elastin fibers to cross-link, which increases stiffness and decreases vascular flexibility. Additionally, they attach to RAGE (Receptor for AGEs), which initiates signaling cascades that worsen inflammation and endothelial dysfunction.

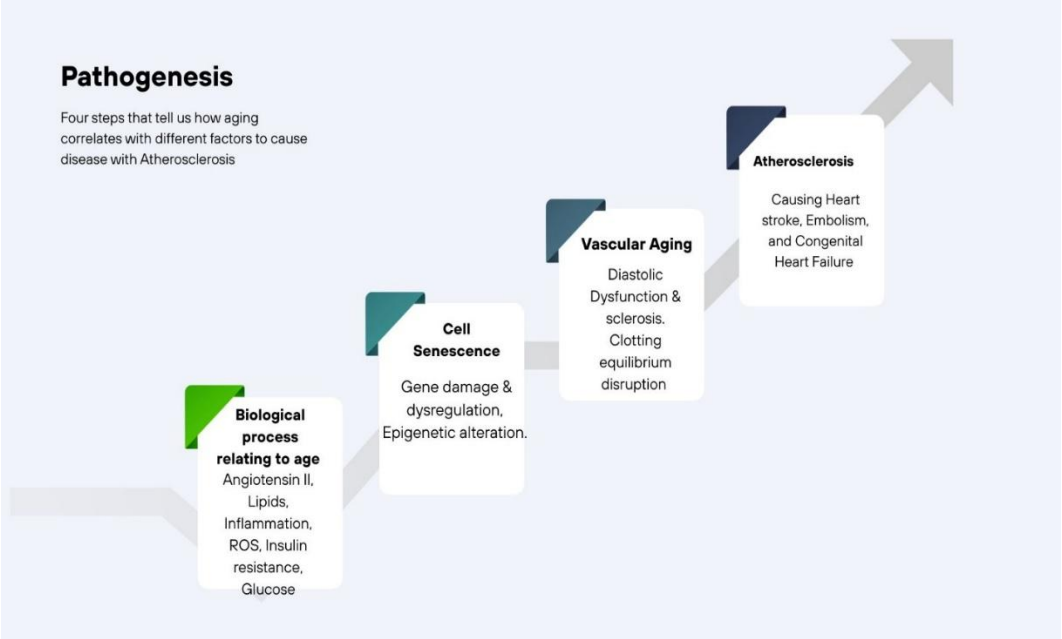
Vascular aging is also characterized by the exhaustion of stem and progenitor cells. Endothelial precursor cells (EPCs) that are in charge of mending damaged endothelium become less numerous and less functional as people age. This decrease speeds up the development of atherosclerotic plaque and hinders the regrowth of

vascular tissue (Ashara et al.,2011). Additionally, vascular aging has been found to differ by sex. By increasing the synthesis of nitric oxide and decreasing oxidative stress, estrogen in premenopausal females protects the vasculature. But estrogen levels fall after menopause, which speeds up vascular aging and raises women's risk of heart disease (Mendelsohn & Karas, 2005).

Finally, the equilibrium among pro- and anti-inflammatory properties immune cells is altered by immune-senescence, the immune system's slow deterioration with aging. According to Furman et al. (2019), aging causes immune responses to change toward an increased pro-inflammatory profile, which exacerbates arterial disease and causes persistent moderate inflammation in the vasculature (Basharat et al., 2024).

These molecular and cellular elements work together to show that vascular aging is an actively controlled biological event including metabolic, inflammatory, and regeneration pathways rather than just a passive degenerative process. By focusing on these pathways, novel approaches to postponing vascular aging and lessening the impact of age-related cardiovascular illnesses may become available.

flow mechanical force



Inflammation and Aging

Inflammaging other name is “chronic infection” main culprit leading to onset of atherosclerotic mechanism specifically in older adults. The chief attributing factor of inflammaging is high level of cytokines such as IL-6(interleukin -6) & tumor necroting factor alpha (TNF- α) leading to extensive atherosclerotic plaques formation (Franceschi et al., 2018). This chronic inflammatory situation aggravates endothelial dysfunction & encourages the development of atherosclerosis by raising oxidative stress & adding inflammatory responses within the arterial walls (Griendling & FitzGerald, 2014). Therefore; it is necessary to highlight relation between aging & inflammation to disclose chronic inflammation as part of maintenance of heart related disorders in older adults.

Inflammation and Aging (Inflammaging)

The concept of "inflammaging" is mainly increasing acknowledgement of aging as a low-grade, lingering, systemic provocative condition (Franceschi et al., 2018). The pathophysiology of many age-related disorders, including as atherosclerosis, diabetes type 2, Alzheimer's disease, and frailty, is influenced by persistent, non-resolving inflammation, as opposed to acute inflammation, which is a beneficial and temporary reaction to damage or infection.

Biological Basis of Inflammaging

Inflammation has a complex etiology that includes both extrinsic and internal components. Senescence-associated secretory phenotypes (SASP) is a pro-inflammatory cocktail of chemokines, growth hormones, and proteases secreted by senescent cells, which is one of the main processes (Birch & Gil, 2020). These secretions promote systemic and local inflammation and alter tissue architecture.

In addition, immune-senescence—a reduction in the repertoire and functionality of both innate as well as adaptive immune cells—occurs as the immune system ages. Natural killer (NK) cell function, macrophage polarization, and T-cell response effectiveness are all affected (Fulop et al., 2022). These alterations make it harder to eliminate inflammation and increase the risk of developing a chronic inflammatory state.

Inflammation is also largely caused by mitochondrial dysfunction. NF-κB and the inflammasome NLRP3 are two significant mediators of related to age inflammation that can be activated by excessive reactive oxygen species (ROS) produced by aged mitochondria (López-Otín et al., 2023).

Furthermore, even in the absence of infection, damage-associated molecular patterns (DAMPs) released by dying or stressed cells function as endogenous danger signals that attach to pattern recognition receptors (PRRs), including Toll-like receptors (TLRs), and set off inflammatory cascades (Zhou et al., 2022).

Clinical Implications of Inflammaging

Inflammation plays an active role in the emergence of progressive illnesses and is not just a biomarker of aging. Functional decline, cognitive decline, sarcopenia, and an increased risk of death are all reliably linked to higher levels of interleukin-6 (IL-6), tumor necrosis factor- alpha (TNF-α), and C-reactive protein (CRP) in the elderly (Ferrucci et al.,2023).By encouraging endothelial failure, stiffness in the arteries, and circulatory smooth muscle cell senescence, recent research further demonstrates that inflammation directly contributes to vascular aging (Al-Ghatrif et al., 2020). By altering lipid metabolism & immune regulation, an prolonged inflammatory micro-environment promotes the development of plaque in atherosclerosis.

Therapeutic Targeting of Inflammaging

Metformin, an antidiabetic agent, is recognized for its ability to activate AMPK, which governs cellular autophagy and mitochondrial dynamics, stimulates sirtuin 1 (SIRT1), inhibits the mTOR pathway, and decreases reactive oxygen species levels; all of which are established mechanisms for obstructing inflammatory cytokine signaling pathways. Animals can live longer and avoid age-related illnesses using rapamycin, an m-TOR inhibitor and another CR mimic. The SASP in senescent cells and cellular autophagy is known to be regulated by the mTOR signaling pathway. It is therefore not surprising that rapamycin inhibits the release of IL-6 from tumor cells and has been demonstrated to cause microglial cells to adopt an anti-inflammatory phenotype.

As a cholesterol synthesis-blocking medication that is frequently administered to patients with CVD, HMG-CoA reductase inhibitors, or statins, have drawn a lot of attention. In addition to their anti-atherosclerotic effects, statins have been shown in clinical in vivo trials to bias immunological responses in favor of an anti-inflammatory response through decreases in CD28-ve senescent T cells. According to in vitro research, statin inhibits TLR-stimulated monocytes' production of cytokines, disrupts DCs' presentation of antigen, skews T cell differentiation toward an anti-inflammatory Th2 and regulatory T cell phenotype, and prevents the growth of Th17 cells. (Dugan et al., 2023b).

ARBs and ACEIs, or angiotensin-converting enzyme inhibitors, are essential medications for controlling vascular inflammation. ARBs stop angiotensin II from binding to its receptors, reducing its harmful effects on the vasculature, while ACEIs block the conversion of angiotensin I to angiotensin II, a strong vasoconstrictor that increases inflammation. Both kinds of medications improve endothelial function

through increased NO bioavailability and reduce vascular inflammation and oxidative stress by lowering angiotensin II levels. (Zeng et al., 2025)

Lifestyle Factors and Cardiovascular Health

A growing amount of research indicates that modifiable lifestyle factors, such as eating habits, exercise habits, cigarette smoking, drinking alcohol, inadequate sleep, and psychosocial stress, are crucial for both the onset and avoidance of cardiovascular disease (CVD), which continues to be the world's leading cause of death (Benjamin et al., 2019).

Our knowledge of the relationship between lifestyle and disease has improved due to recent data on non-traditional determinants of cardiometabolic health. Numerous conventional and non-traditional intermediate pathways linked to ASCVD are impacted by long-term exposure to environmental stressors such as poor diet quality, sedentarism, ambient air pollution and noise, sleep deprivation, and psychosocial stress. These include the intestinal microbiota, muscle strength and function, body composition, and cardiorespiratory fitness, all of which are becoming more widely acknowledged as important factors influencing cardiovascular health.

There is evidence of partially overlapping mechanisms, such as impacts on autophagy, endocrine signaling, autonomic function, and inflammatory and sensing of nutrients pathways. The possibility that low-risk lifestyle factors may influence plaque vulnerability by changing the phenotype and secretome of skeletal muscle and adipose tissue is especially pertinent. Collectively, low-risk lifestyle factors cause a set of phenotypic adaptations shifting tissue cross-talk from a proinflammatory milieu conducive for high-risk atherosclerosis to an anti-atherogenic milieu *(*Zeng et al. (2025).

Diet and Nutrition

Up to nearly half of all deaths from CVD are caused by dietary decisions, making them the most significant variables compromising health and wellbeing.There is compelling evidence that dietary variables can either directly or indirectly affect the development of atherosclerosis by influencing conventional risk factors such blood pressure, plasma glucose, and plasma lipids. Nevertheless, randomized clinical trials (RCTs) with specific goals only provide a portion of this evidence. (Riccardi et al., 2021)

According to the research, diets that include more plant-based meals and less refined cereal and starchy foods are linked to a significantly lower risk of cardiovascular disease than diets that primarily consist of animal products. When interpreted at the general population level, the found decreases in relative risks, while their modest magnitude, may have an enormous effect on overall cardiovascular risk and, consequently, the number of events. (Riccardi et al., 2021)

The jeopardy of CVD is upstretched by Western-style diets, which are related with higher stages of arterial strenuousness, being weighty, confrontation to insulin, and systemic inflammation. These diets are typified by a high intake of red meats, processed meals, sugar, and saturated fats (Lichtenstein et al., 2021).

Physical Activity and Sedentary Behavior

Frequent resistance and aerobic exercise increases lipid metabolism, lowers blood pressure, and improves endothelial function (Piercy et al., 2018). The World Health Organization suggests engaging in moderate-intensity aerobic exercise for at least 150 to 300 minutes each week. On the contrary, despite physical activity lavish living states mainly sitting for long time linked to a high chance of stroke and heart attack (Patterson et al., 2018).

Smoking and Alcohol Use

One of the most avoidable causes of cardiovascular disease is still cigarette smoking. According to Messner and Bernhard (2014), it encourages oxidative stress, damage to endothelial cells, hypercoagulability, and atherosclerosis. Even among long-time smokers, quitting smoking quickly lowers the risk of CVD.

Alcohol plays a variety of roles. Recent large-scale studies highlight that no level of alcohol consumption is totally safe, especially given its connection to hypertension,

arrhythmias, and cardiomyopathy. However, polyphenols in light to moderate intake, particularly red wine, have been linked to some cardiovascular benefits (GBD 2016 Alcohol Collaborators, 2018; Piano, 2017).

Sleep and Circadian Rhythm

Short sleep duration (less than 6 hours), poor sleep quality, and sleep disorders including obstructive sleep apnea, are all risk factors for stroke, heart disease, and high blood pressure (Gupta et al., 2017). According to recent studies, shift work and other forms of circadian misalignment can contribute to metabolic and vascular problems (Rana et al., 2023).

Stress and Psychosocial Health

Depression, anxiety, and chronic psychological stress are strongly linked to higher rates of CVD and worse outcomes after MI. These variables can cause inflammation, elevated cortisol, neuroendocrine activation, and sympathetic nervous system stimulation, all of which compromise blood vessel health (Steptoe & Kivimäki, 2019).

Combined Lifestyle Factors

According to recent cohort studies, adopting a variety of healthy lifestyle practices considerably lowers the death rate from CVD and lengthens life expectancy.People maintaining ideal weight according to Body Mass Index (BMI) sleep cycle & refrain from smoking of any type with usage of alcohol beverages expected to be living free of lingering illness inclusive of hearth disease up to 10 to 14 years more(Li et al,2020).

In context of aging; living conditions mainly influence the formation and spreading of atherosclerosis. Diet, physical exercises Smoking, alcohol are debatable factors affecting heart disease like heart attack and heart damage. Saturated fats i.e cholesterol fatty acid containing food and carbonated sugar cause high level of Loe density lipid (LDL) and extensive systemic inflammation contributing to the formation of atherosclerotic plaques. (Piepoli et al., 2016). Conversely, diets rich in fruits, vegetables, whole grains, and omega-3 fatty acids have been shown to reduce inflammation and improve endothelial function. Regular physical activity has beneficial effects on cardiovascular health by improving endothelial function, reducing arterial stiffness, and lowering blood pressure (Choi et al., 2020).

Additionally, smoking accelerates the development of atherosclerosis by increasing oxidative stress and promoting inflammatory responses (Ambrose & Ramachandran, 2015). Thus, lifestyle modifications play a crucial role in mitigating the impact of aging on cardiovascular health.

Table: The Interplay between Aging and Atherosclerosis

Category	Details	ShortReference
Aging Factors	**Structural Changes**: Amplified arterial toughness, solidifying of arterial walls. Left ventricular hypertrophy.	(Lakatta, 2015)
	Functional Changes: Endothelial dysfunction, concentrated elasticity. Murmur sounds & Sino-arterial node (SA) disfunction	(Grier, Kumar, & Herrmann, 2019)
Pathogenesis of Atherosclerosis	**Endothelial Dysfunction**: Enlarged permeability, oxidative stress. ED disruption leads the routine functioning of the cells of endothelial layer, causing reduction of NO manufacture (a central vasodilator) triggering amplified vessels constriction. It demonstrated as augmented adhesion of molecule countenance,	(Griendling & FitzGerald, 2014)

	leukocyte attachment, and extensive low-density lipids (LDL) oxidation	
	Plaque Formation: damage to internal layers of arteries, oxidizes LDL cholesterol deposition, leading to foam cell formation by white cell causing fibrous cap formation in plaque by smooth muscles adherence & inflammatory cells	(Libby, 2013)
Inflammatory Processes	**Chronic Inflammation**: Prominent pro-inflammatory cytokines (e.g., IL-6, TNF-α, IL-1, INF), inflammatory milieu in arteries by proteases causing weaking of fibrous cap & more prone to Rupture ultimately causing rupture.	(Franceschi et al., 2018)
Lifestyle Factors	**Diet**: High in saturated fats and cholesterol, fruits, vegetables, omega-3 fatty acids	(Piepoli et al., 2016)
	Physical Activity: Upgraded endothelial function, concentrated arterial stiffness	(Choi, Kim, & Cho, 2020)
	Smoking: Amplified oxidative stress on lungs and reducing capability to carry oxygen	(Ambrose & Ramachandran, 2015)
Health Outcomes	**Atherosclerosis Progression**: Lessening of arteries, danger of cardiovascular events (e.g., heart attack, stroke, gangrene & CKD (chronic kidney disease) sometimes also lead to mesenteric artery ischemia.	(Grier, Kumar, & Herrmann, 2019)

Prevention and Management Strategies for Aging and Atherosclerosis

The onset of atherosclerosis with age is unavoidable and it can greatly be influenced by lifestyles, medication and future therapeutic medication.

Lifestyle Modifications

The mainstay of atherosclerosis anticipation, mainly in the elderly population, stays to be lifestyle modifications. Regular aerobic workout has been proven to lessen the age-related arterial stiffness by enhancing nitric oxide bioavailability, improving endothelial function, and lowering oxidative stress (Donato et al., 2018). In older adults, a diet high in vegetables, whole grains, fruits, nuts, and olive oil is also linked to a lessened danger of inflammation & atherosclerotic events (Rosato et al., 2019).

Blood Pressure and Lipid Control

It's crucial to treat dyslipidemia and hypertension. Statins are very effective at stumbling the advancement of atherosclerosis in the aging-population because they not only lessen LDL cholesterol but also have anti-inflammatory and plaque-stabilizing characteristics (Ridker et al., 2019). According to current studies, statins remain to be accommodating in persons over 75 without triggering serious side effects (Orkaby et al., 2020).

Anti-Inflammatory Therapies

Myocardial infarction, stroke, and ischemia gangrene are all brought on by atherosclerosis, an inflammatory condition. Low-density lipoproteins that carry cholesterol build up in the intima and cause the endothelium to become activated, which starts the atherosclerotic process. Chemokines and leukocyte adhesion molecules encourage the recruitment of T cells and monocytes. When monocytes develop into macrophages, they increase the expression of pattern recognition receptors, such as toll-like and scavenger receptors. Foam-cell production results from the internalization of lipoproteins, which is mediated by scavenger receptors. Proteases, vasoactive molecules, and cytokines are released as a result of activating signals sent by toll-like receptors. Local antigens are recognized by T cells in lesions, which then activate T

helper-1 responses by secreting pro-inflammatory cytokines that promote local inflammation and plaque formation.Ischemia and infarction can result from local proteolysis, plaque bursting, and thrombus development brought on by increased inflammatory activity. Anti-inflammatory medication may be helpful to limit disease activity, and inflammatory markers are currently utilized for tracking the disease process. (Hansson et al., 2006)

Directing inflammatory pathways is a practical tactic because chronic inflammation is a chief factor in vascular aging. Anti-inflammatory medicines may help avert atherosclerosis in older persons, as evidenced by the CANTOS trial (Canakinumab Anti-inflammatory Thrombosis Outcome Study), which showed that IL-1β suppression lowers cardiovascular events regardless of lipid levels (Ridker et al., 2017).

Gut Microbiota Regulation

Recent research suggest that Trimethylamine-N-Oxide (TMAO) is a molecule causing atherosclerosis; Controlling development of this molecule may reduce chances of deterioration of cardiac health by changing gut normal flora. Diets such as prebiotics, dietary fibers & prebiotics help in maintenance of gut normal flora and reduce gut recurrent inflammation. In order to mitigate atherosclerosis risk, probiotics, prebiotics, & dietary fiber can enhance gut health and lower systemic inflammation (Witkowski et al., 2020).

Conclusion

Rigidity of arteries, malfunctioning of cells of endothelial layer of vessels & increasing contributing factor to atherosclerotic plaque formation are the primary contributing reason of cardiac aging that is multidimensional proceeding defined by physiological & structural changes in arteries. Aging fuels vascular disorders by compilation of indicators like deposition of collagen molecules, breakdown of elastin & sustained minimal lingering inflammation occasionally, termed as "inflammaging". (Lakatta,2015; Donato et al.,2018).

New researches indicate that gut normal flora affects cardiac health by formation of pro-inflammatory molecular compounds i.e. TMAO. New Therapeutic directions are provided by findings that mainly aim normal flora of human. (Witkowski et al., 2020).

Risk factor for cardiovascular diseases is intricated on gender variables i.e. postmenopausal women are more prone to inflammation of blood vessels and malfunctioning of metabolism (Reid et al., 2021).

In context of these findings, changes in living conditions such as sticking to balanced diet, physical activity, nonsmoking and managing anxiety factors can markedly hinder or stop the start of cardiac disease (Rosato et al., 2019).

Remarkable advantages have been shown by pharmaceutical management of anti-inflammation drugs such as cana-kinumab & statins markedly in elderly with high exposure to cardiac diseases. (Ridker et al., 2017; Orkaby et al., 2020).

Additionally, Recent advance strategies such as senolytics & calorie balanced diet show remarkable results in emphasizing ongoing age-related mechanism at cellular stage that assist to alter or delay cardiac aging (Xu et al., 2018).

At the end conclusively, Aging is undeniable threat although it effects are more.

It is necessary to main cardiac health in aged populations & reducing the stress of risk factors to atherosclerosis and it needs as multifactored plan that adds GIT (gastrointestinal tract) health modules, gender-based strategies, life optimizing, clinical maintenance & tailed treatment plans.

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