

# Cardiovascular Complications of Diabetes Mellitus Mechanisms and Therapeutic Interventions

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## Introduction

Diabetes Mellitus (DM) is a chronic metabolic disorder characterized by elevated blood glucose levels due to either insufficient insulin production (Type 1 DM) or impaired insulin action (Type 2 DM). Over the years, diabetes has evolved into a global epidemic, affecting millions of individuals worldwide. Apart from its well-established effects on glucose metabolism, diabetes also exerts a profound impact on the cardiovascular system, leading to an increased risk of various cardiovascular complications [1]. This article delves into the mechanisms underlying cardiovascular complications in diabetes and discusses therapeutic interventions aimed at mitigating these risks.

## Description

### Mechanisms of cardiovascular complications in diabetes

The relationship between diabetes and cardiovascular complications is multifaceted, involving a complex interplay of various pathophysiological mechanisms [2]. These mechanisms are driven by the chronic hyperglycemia, insulin resistance and associated metabolic disturbances that characterize diabetes.

- 1. Endothelial dysfunction:** Hyperglycemia contributes to endothelial dysfunction, characterized by impaired Nitric Oxide (NO) production, reduced vasodilation and increased endothelin-1 levels. This compromised endothelial function leads to impaired regulation of vascular tone and promotes atherosclerosis.
- 2. Atherosclerosis:** Diabetes accelerates the development of atherosclerosis, the formation of fatty plaques in arteries. Inflammation, oxidative stress and endothelial dysfunction play pivotal roles in this process. Additionally, Advanced Glycation End-products (AGEs) formed due to chronic hyperglycemia contribute to vascular inflammation and atherosclerotic plaque formation.
- 3. Oxidative stress:** Increased oxidative stress in diabetes leads to the generation of reactive oxygen species (ROS), which damage cellular components and exacerbate vascular dysfunction. This oxidative stress promotes endothelial dysfunction, inflammation and vascular remodeling.
- 4. Inflammation:** Chronic low-grade inflammation is a hallmark of diabetes and is closely associated with cardiovascular complications. Inflammatory cytokines, such as interleukin-6 (IL-6) and tumor

necrosis factor-alpha are elevated in diabetes and contribute to the development and progression of atherosclerosis.

- 5. Hyperlipidemia:** Dyslipidemia, including elevated levels of triglycerides and Low-Density Lipoprotein Cholesterol (LDL-C), is frequently observed in diabetes. These lipid abnormalities contribute to the formation of atherosclerotic plaques and increase the risk of cardiovascular events.
- 6. Hypercoagulability:** Diabetes is associated with an increased tendency towards blood clot formation, which can lead to thrombotic events such as myocardial infarction and stroke. Altered platelet function and impaired fibrinolysis contribute to this hypercoagulable state.

### Types of cardiovascular complications

Diabetes predisposes individuals to a range of cardiovascular complications, which can be broadly categorized into macrovascular and microvascular complications.

#### Macrovascular complications:

- 1. Coronary Artery Disease (CAD):** CAD, also known as ischemic heart disease, results from the buildup of atherosclerotic plaques in the coronary arteries [3]. This condition significantly increases the risk of heart attacks (myocardial infarctions) and angina.
- 2. Stroke:** Atherosclerosis affecting the cerebral arteries can lead to stroke, causing damage to brain tissue. Individuals with diabetes are at an elevated risk of both ischemic and hemorrhagic strokes.
- 3. Peripheral Arterial Disease (PAD):** PAD involves narrowing of the arteries that supply blood to the extremities, most commonly the legs. This can lead to claudication (pain during walking) and increase the risk of non-healing ulcers and amputations.

#### Microvascular complications:

- 1. Diabetic retinopathy:** High blood sugar levels damage the small blood vessels in the retina, leading to vision impairment and, if left untreated, blindness.
- 2. Diabetic nephropathy:** Chronic kidney disease resulting from diabetes-related damage to the small blood vessels in the kidneys [4]. It can progress to end-stage renal disease, necessitating dialysis or kidney transplantation.
- 3. Diabetic neuropathy:** Nerve damage due to diabetes affects various body parts, leading to symptoms like tingling, numbness, pain and muscle weakness. Autonomic neuropathy can also disrupt heart rate and blood pressure regulation.

### Therapeutic interventions

The management of cardiovascular complications in diabetes involves a multi-faceted approach, targeting glycemic control, blood pressure management, lipid levels and lifestyle modifications [5].

- 1. Glycemic control:** Maintaining optimal blood glucose levels is crucial for reducing the risk of cardiovascular complications. This can be achieved through dietary modifications, physical activity and

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appropriate use of glucose-lowering medications, including insulin and oral hypoglycemic agents.

2. **Blood pressure management:** Hypertension is common in individuals with diabetes and significantly contributes to cardiovascular complications. Lifestyle changes, such as reducing sodium intake, losing weight and increasing physical activity, are essential. Antihypertensive medications, such as ACE inhibitors and Angiotensin II Receptor Blockers (ARBs), are often prescribed to manage blood pressure and protect kidney function.
3. **Lipid management:** Statins are the cornerstone of lipid-lowering therapy in diabetes. These medications effectively reduce LDL-C levels and have been shown to lower the risk of cardiovascular events. Additionally, lifestyle modifications, such as adopting a heart-healthy diet and increasing physical activity, can improve lipid profiles.
4. **Antiplatelet therapy:** As individuals with diabetes have an increased risk of clot formation, antiplatelet agents like aspirin are often prescribed to reduce the risk of cardiovascular events.
5. **Lifestyle modifications:** Encouraging lifestyle changes is essential for managing cardiovascular complications in diabetes. These include adopting a balanced diet rich in fruits, vegetables, whole grains and lean proteins, maintaining a healthy weight, engaging in regular physical activity, quitting smoking and moderating alcohol consumption.
6. **Novel therapies:** Over the years, several novel therapeutic approaches have emerged to address cardiovascular complications in diabetes. Sodium-Glucose cotransporter-2 (SGLT-2) inhibitors and Glucagon-Like Peptide-1 (GLP-1) receptor agonists, originally developed as glucose-lowering medications, have shown remarkable cardiovascular benefits. SGLT-2 inhibitors reduce the risk of heart failure hospitalizations and cardiovascular death, while GLP-1 receptor agonists improve cardiovascular outcomes and reduce the risk of major adverse cardiovascular events.

## Conclusion

In conclusion, diabetes mellitus poses a significant risk for cardiovascular complications due to its impact on various pathophysiological mechanisms. These complications, ranging from atherosclerosis and hypertension to diabetic retinopathy and neuropathy, contribute to increased morbidity and mortality in individuals with diabetes. Effective therapeutic interventions involve a holistic

approach that includes glycemic control, blood pressure management, lipid control and lifestyle modifications. Emerging therapies, such as SGLT-2 inhibitors and GLP-1 receptor agonists, have added new dimensions to the management of cardiovascular complications in diabetes. However, early detection, regular monitoring and comprehensive care remain crucial for minimizing the impact of diabetes-related cardiovascular complications on patients' lives.

## Acknowledgement

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## Conflict of Interest

None.

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