

HEMODYNAMICS STUDY OF THE EFFECTS OF SUGAR AND OIL IN A MOCK CIRCULATORY LOOP

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ABSTRACT

Diabetes mellitus and hypercholesterolemia are the most prevalent metabolic disorders worldwide and are strongly associated with cardiovascular complications. Elevated blood glucose and lipid levels alter blood rheology by increasing viscosity and flow resistance, contributing to hypertension and vascular dysfunction. While understanding these hemodynamic changes is critical for clinical research and biomedical engineering education, direct human studies are often limited by ethical and practical constraints. To address this challenge, a mock circulatory loop (MCL) was used as a controlled, reproducible in vitro platform to investigate the effects of sugar and oil concentrations on arterial pressure dynamics.

A dual-pump hybrid MCL was designed to replicate human cardiovascular physiology using elastic silicone tubing and pressure sensors to model the systemic circulation. Four blood-analog fluid formulations were prepared to simulate combinations of high and low sugar and oil content. Each solution was circulated through the MCL, and pressure waveforms were recorded for three independent cycles.

The experimental results demonstrated clear differences in hemodynamic response across fluid formulations. The high-sugar–high-oil formulation produced the highest pressures, averaging 133/63 mmHg, while the low-sugar–low-oil formulation yielded lower pressures of 122/60 mmHg. These findings align with established physiological principles, in which elevated glucose and lipid levels increase fluid viscosity and alter flow dynamics.

Overall, this study demonstrates that MCL can effectively simulate viscosity-related hemodynamic trends associated with metabolic conditions. The platform provides a safe, repeatable, and educationally valuable environment for studying cardiovascular hemodynamics and supports both translational research and biomedical engineering training.

Keywords: mock circulatory loop, hemodynamics, diabetes, hypercholesterolemia, cardiovascular

INTRODUCTION

Diabetes mellitus and hypercholesterolemia are among the most prevalent metabolic disorders worldwide and are strongly associated with adverse cardiovascular outcomes [1]. Chronic elevations in blood glucose and lipid concentrations alter blood rheology by increasing viscosity and flow resistance, contributing to hypertension, vascular dysfunction, and increased cardiovascular risk [2]. Understanding the hemodynamic consequences of these metabolic conditions is therefore essential for cardiovascular research, medical device development, and translational studies.