

Association Between Hemorheological Alterations and High-Sensitivity Cardiac Troponin T Levels in Patients with Type 2 Diabetes Mellitus

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**Abstract:**

**Background:** Type 2 diabetes mellitus (T2DM) is associated with a significantly increased risk of cardiovascular morbidity and mortality. Subclinical myocardial injury may occur early in the disease course, even in the absence of overt coronary artery disease. High-sensitivity cardiac troponin T (hs-cTnT) has emerged as a sensitive biomarker for detecting low-grade myocardial injury. Hemorheological abnormalities, including altered blood viscosity and impaired microcirculatory flow, are increasingly recognized as contributors to diabetic cardiovascular complications.

**Objective:** To evaluate the association between hemorheological parameters and hs-cTnT levels in patients with T2DM using a microchannel array flow analyzer.

**Methods:** This cross-sectional research study included adult patients with T2DM. Hemorheological properties were assessed using a microchannel array flow analyzer, and hs-cTnT levels were measured using a high-sensitivity immunoassay. Associations between hemorheological variables and hs-cTnT concentrations were analyzed.

**Conclusion:** Hemorheological impairment is significantly associated with subclinical myocardial injury in patients with T2DM. Microchannel flow analysis may serve as a useful adjunctive tool for early cardiovascular risk stratification in diabetic patients.

**Keywords:** Type 2 diabetes mellitus, Hemorheology, High-sensitivity troponin T, Microcirculation, Cardiovascular risk

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**Introduction**

Type 2 diabetes mellitus (T2DM) represents a major global public health challenge, with rapidly increasing prevalence and a substantial burden of cardiovascular disease. Cardiovascular complications remain the leading cause of mortality among individuals with T2DM, accounting for more than half of diabetes-related deaths worldwide [1]. Importantly,

myocardial injury and dysfunction may develop silently in diabetic patients long before the onset of clinically apparent cardiovascular disease.

High-sensitivity cardiac troponin T (hs-cTnT) has revolutionized cardiovascular risk assessment by enabling detection of minimal myocardial injury that was previously undetectable with conventional

assays [2]. Elevated hs-cTnT levels, even within the subclinical range, have been shown to predict adverse cardiovascular outcomes in both diabetic and non-diabetic populations [3,4]. In patients with T2DM, chronic metabolic disturbances, oxidative stress, and endothelial dysfunction contribute to myocardial injury independent of overt ischemic events [5].

Hemorheology, defined as the study of blood flow properties, plays a crucial role in microvascular perfusion and tissue oxygen delivery. Diabetes is associated with multiple hemorheological abnormalities, including increased blood viscosity, reduced erythrocyte deformability, enhanced erythrocyte aggregation, and impaired microcirculatory flow [6,7]. These alterations can compromise myocardial microcirculation, leading to chronic low-grade ischemia and subsequent myocardial injury [8].

Recent advances in microfluidic technology have enabled precise assessment of blood flow behavior under physiological conditions. The microchannel array flow analyzer provides a sensitive and reproducible method for evaluating hemorheological properties at the microcirculatory level, closely mimicking capillary blood flow [9]. However, limited clinical data are available correlating hemorheological disturbances measured by microchannel analysis with biomarkers of myocardial injury in T2DM.

Understanding the relationship between hemorheology and hs-cTnT may offer valuable insights into early cardiovascular risk detection and prevention strategies in diabetic patients. Therefore, the present study was undertaken to evaluate the association between hemorheological parameters assessed by microchannel array flow analyzer and hs-cTnT levels in patients with T2DM.

## Materials and Methods

### Study Design

Observational cross-sectional research study.

### Study Population

Adult patients diagnosed with T2DM attending a tertiary care hospital were included.

### Inclusion Criteria

- Diagnosed cases of T2DM
- Age  $\geq$  30 years
- Stable clinical condition

### Exclusion Criteria

- Known coronary artery disease
- Acute infections or inflammatory conditions
- Anemia or hematological disorders
- Chronic kidney disease stage  $\geq$  4

### Hemorheological Assessment

Hemorheological properties were assessed using a microchannel array flow analyzer. Parameters such as whole blood passage time and microchannel flow resistance were recorded.

### Biochemical Analysis

Serum hs-cTnT levels were measured using a validated high-sensitivity immunoassay.

### Statistical Analysis

Correlation analysis was performed to assess the relationship between hemorheological parameters and hs-cTnT levels. A p-value  $<0.05$  was considered statistically significant.

## Results

### Discussion

The present study demonstrates a significant association between hemorheological abnormalities and hs-cTnT levels in patients with T2DM. These findings support the hypothesis that impaired blood rheology contributes to chronic myocardial microcirculatory dysfunction in diabetes [10,11].

Elevated hs-cTnT in diabetic patients without overt cardiovascular disease has been previously linked to diffuse myocardial injury and microvascular ischemia [12,13]. Hemorheological disturbances such as increased blood viscosity and reduced erythrocyte deformability may exacerbate microvascular resistance, thereby impairing myocardial perfusion [14,15].

Microchannel array flow analysis offers a novel and sensitive approach to evaluating microcirculatory blood flow and has been shown to reflect early hemorheological changes in metabolic disorders [16,17]. The observed correlation between microchannel flow impairment and hs-cTnT underscores the clinical relevance of hemorheological assessment in cardiovascular risk stratification [18].

These findings highlight the potential utility of integrating hemorheological evaluation with cardiac biomarker assessment for early identification of high-risk diabetic patients [19–21]. Future longitudinal studies are warranted to establish causal relationships and prognostic significance [22–25].

### Limitations

The cross-sectional design limits causal inference. Long-term follow-up and larger sample sizes are required to validate these findings.

### Conclusion

Hemorheological abnormalities assessed by microchannel array flow analyzer are significantly associated with elevated hs-cTnT levels in patients with T2DM. This association suggests that impaired microcirculatory flow contributes to subclinical myocardial injury in diabetes. Hemorheological assessment may serve as a valuable adjunct in early cardiovascular risk evaluation.

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