CLIMATIC TRIGGERS AND MYOCARDIAL STRUCTURAL REMODELING IN ISCHEMIC HEART DISEASE: A FORENSIC–MORPHOLOGICAL STUDY

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ABSTRACT

Ischemic heart disease (IHD) remains one of the leading causes of mortality worldwide. Despite significant progress in modern cardiology, sudden cardiac death associated with ischemic myocardial damage continues to represent a major medical and forensic problem. The clinical course and complications of IHD are influenced not only by classical cardiovascular risk factors but also by environmental and climatic conditions.

Introduction

Ischemic heart disease (IHD) remains one of the leading causes of mortality worldwide. Despite significant progress in modern cardiology, sudden cardiac death associated with ischemic myocardial damage continues to represent a major medical and forensic problem. The clinical course and complications of IHD are influenced not only by classical cardiovascular risk factors but also by environmental and climatic conditions.

In regions characterized by continental climate patterns, seasonal fluctuations in temperature and atmospheric conditions can significantly affect cardiovascular physiology. Low ambient temperatures provoke peripheral vasoconstriction, increased arterial pressure, activation of the sympathetic nervous system, and increased blood viscosity. These physiological reactions result in elevated myocardial oxygen demand and may trigger ischemic events in individuals with compromised coronary circulation.

Previous epidemiological studies have demonstrated that the incidence of acute coronary events and cardiovascular mortality tends to increase during cold seasons. However, the structural myocardial alterations underlying these seasonal variations remain insufficiently characterized, particularly from a forensic morphological perspective.

Understanding the histological and morphometric changes in myocardial tissue associated with ischemic heart disease during colder seasons may improve the diagnostic accuracy of sudden cardiac death and provide additional insights into the pathophysiological mechanisms involved.

The aim of this study was to evaluate macroscopic and microscopic myocardial changes in individuals who died from ischemic heart disease during the winter period and to assess their morphological characteristics from a forensic medical perspective.

Materials and Methods

This study was conducted at the Samarkand branch of the Republican Scientific and Practical Center for Forensic Medicine between 2021 and 2025. Materials from forensic autopsies of individuals who died suddenly due to ischemic heart disease during the winter season were analyzed.

A total of **42 cases** were included in the study. All cases underwent standard forensic autopsy procedures, including macroscopic examination of the heart and histological analysis of myocardial tissue.

Myocardial samples were fixed in a 10% neutral formalin solution and subsequently processed through standard histological preparation protocols, including dehydration, paraffin embedding, and staining. Microscopic examination was performed using a **NanoZoomer scanning microscope (Hamamatsu Photonics, Japan)**.

Histomorphometric measurements were obtained using **NDP.View 2.0 software**, allowing detailed analysis of cardiomyocyte diameter, nuclear morphology, and interstitial space.

Statistical analysis was performed using **Microsoft Excel 2021**, and differences between parameters were evaluated using Student's t-test.

Results

Analysis of the circumstances of death demonstrated that most sudden cardiac deaths occurred outside medical facilities. Among the 42 examined cases, 25 deaths occurred at home, 16 occurred outdoors, and one occurred in a workplace environment, indicating the rapid progression of fatal ischemic events.

Age distribution analysis revealed that the majority of deaths occurred between 45 and 74 years, accounting for 85.7% of all cases.

Macroscopic examination of the heart demonstrated pronounced hypertrophic changes. The mean heart weight was 420 ± 40 g, which exceeded normal physiological values. The thickness of the left ventricular wall averaged 1.6 ± 0.2 cm, indicating concentric hypertrophic remodeling.

Histological analysis revealed several structural alterations in myocardial tissue, including:

- disorganization of cardiomyocyte fibers
- nuclear hypertrophy and hyperchromasia
- expansion of interstitial spaces
- perivascular congestion
- interstitial edema
- focal fibrosis

These changes reflect chronic ischemic damage and structural remodeling of the myocardium associated with prolonged hemodynamic stress.

Table 1

Macroscopic characteristics of the heart in sudden death cases associated with IHD

Parameter	Mean value (M±m)	Physiological norm	Interpretation
Heart weight (g)	420 ± 40	300–350	Myocardial hypertrophy

Heart length (cm)	13.8 ± 0.7	12–13	Slight enlargement
Heart width (cm)	11.2 ± 0.6	8–10	Chamber dilation
Total heart thickness (cm)	6.8 ± 0.5	5–6	Hypertrophic remodeling
Left ventricular wall thickness (cm)	1.6 ± 0.2	1.1–1.4	Concentric hypertrophy

Discussion

The results of this study demonstrate significant structural alterations in myocardial tissue associated with ischemic heart disease during the winter season. The observed morphological changes reflect adaptive and pathological responses of the myocardium to increased hemodynamic stress caused by cold-induced physiological reactions.

Cold exposure leads to increased systemic vascular resistance and elevated arterial pressure, which subsequently increases myocardial workload. In individuals with preexisting coronary artery disease, these changes may accelerate ischemic injury and structural remodeling of myocardial tissue.

The predominance of hypertrophic remodeling and interstitial edema observed in this study suggests that chronic ischemic processes are intensified under cold environmental conditions. Similar findings have been reported in epidemiological and pathological studies examining seasonal patterns in cardiovascular mortality.

From a forensic medicine perspective, identifying these structural myocardial changes is essential for determining the cause and mechanism of sudden cardiac death. Morphological evaluation provides objective evidence supporting ischemic cardiac pathology and helps distinguish natural cardiac death from other potential causes.

Conclusion

This study demonstrates that winter-associated ischemic heart disease is characterized by pronounced structural remodeling of myocardial tissue. Macroscopic examination revealed increased heart weight and thickening of the left ventricular wall, while histological analysis identified cardiomyocyte disorganization, nuclear hypertrophy, interstitial edema, and fibrotic changes.

These morphological findings indicate intensified ischemic-dystrophic processes in the myocardium during cold seasons. Recognition of such seasonal pathological patterns may improve forensic diagnostic accuracy and contribute to a better understanding of environmental influences on cardiovascular mortality.

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УЛУЧШЕНИИ ТЕЧЕНИЯ ХРОНИЧЕСКОЙ БОЛЕЗНИ ПОЧЕК У БОЛЬНЫХ С САХАРНЫМ ДИАБЕТОМ. EDITOR COORDINATOR, 309