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# Chronic Heart Failure and Rheological Condition a Review Article

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**Abstract:** Chronic heart failure represents a multifaceted clinical condition characterized by impaired cardiac contractility and/or reduced filling capacity. The prevalence of heart failure shows a strong correlation with age, varying significantly across different populations. In developed regions, the incidence of age-related heart failure has shown a slight decline, largely due to advancements in cardiovascular disease management; however, morbidity rates and long-term outcomes remain concerning. Identifying etiological factors is crucial for enhancing treatment approaches and patient outcomes. This review explores the anticipated alterations in rheological parameters, focusing on specific phenotypes and functional classes, as these factors serve as potential indicators of disease progression severity in chronic heart failure patients.

**Keywords:** Chronic heart failure, Hemorheology, Erythrocyte aggregation.

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## INTRODUCTION

Cardiovascular diseases are the most common health issue worldwide. Among these, heart failure stands out as a major disorder affecting cardiac performance [1]. The World Health Organization (WHO) reports that nearly 17.9 million people lose their lives to these conditions annually [2]. Heart failure is becoming more common as time goes on [3]. The annual mortality rate for heart failure varies widely, falling between 25% and 75% [4]. Factors like age, genetics, social conditions, and subclinical elements play a role in the progression of the disease. Its symptoms are largely linked to different levels of left ventricular dysfunction, ranging from a normal size and volume with preserved ejection fraction (HFpEF) to enlarged ventricles with increased volume and reduced ejection fraction (low EF) [5]. A combined cohort study from the Framingham Heart Study (FHS) and the Cardiovascular Health Study (CHS) revealed that 67% of patients diagnosed with heart failure died within five years [6]. The prognosis for those with mild to moderately reduced ejection fraction tends to be more favorable compared to those with severely impaired ejection fraction [7]. The leading causes of heart failure include ischemic heart disease, myocardial infarction, arterial hypertension, and valvular diseases. Other contributing factors are familial cardiomyopathies, congenital and genetic heart conditions, myocarditis, autoimmune and rheumatoid disorders, chemotherapy and other cardiotoxic drugs, infiltrative heart diseases, and endocrine or metabolic abnormalities [8-10]. The outlook for patients with heart failure remains poor if the underlying condition is not addressed [11]. The functional classification of heart failure often shows a progressive decline. Symptoms tend to worsen over time, even with treatment, as left ventricular function deteriorates. Occasionally, the clinical symptoms may not align with the severity of heart muscle dysfunction. However, when symptoms persist despite therapy, it typically signals a poor prognosis [12]. In this study, we aimed to evaluate expected changes in hemorheological properties based on different heart failure phenotypes and functional classes. Our goal was to explore the potential role of hemorheological parameters in the early detection of heart failure to enable more effective treatment. Heart failure is a condition that progressively worsens over time. The European Association of Cardiology defines it as a combination of clinical symptoms, either at rest or during physical activity, resulting from systolic or diastolic dysfunction of the heart. This dysfunction must be objectively verified through imaging studies [13].

Heart failure is not classified as a disease but rather as a syndrome—a collection of signs and symptoms arising from the heart's inability to pump sufficient blood to meet the body's needs, either at rest or during physical activity. This condition is caused by systolic or diastolic dysfunction of the heart muscle and is confirmed through imaging studies [13]. The New York Heart Association (NYHA) functional classification is the simplest system used to describe the severity of heart failure [14]. It is important to note that the classification of heart failure is based solely on symptoms. From a pathophysiological perspective, heart failure results from systolic dysfunction, diastolic dysfunction, or a combination of both [15]. Etiologically, heart failure can be categorized into left ventricular failure, isolated right ventricular failure, and biventricular failure [16].

Traditionally, separate phenotypes of heart failure have been distinguished based on the values of the left ventricular ejection fraction [17]; three groups of phenotypes are distinguished: Group I - patients with heart failure with severely reduced ejection fraction (HFrEF), where the fraction is less than 40% (LVEF≤40%), Group II - patients with mildly reduced ejection fraction (HFmrEF), in this group the value of the fraction is 41%-49% and Group III - patients with preserved ejection fraction (HFpEF), where the value is equal/higher than 50% (LVEF≥50%), but the patients have clinical symptoms and signs of heart failure, confirmed structural and/or functional impairment of the heart and/or elevated blood natriuretic peptide levels (NPs) [18].

Diagnosing heart failure involves carefully assessing common cardiac symptoms, such as shortness of breath, orthopnea, paroxysmal nocturnal dyspnea, reduced exercise tolerance, fatigue, weakness, and prolonged recovery time after exertion. Less typical but still significant symptoms include nighttime coughing, dry wheezing, bloating, loss of appetite, difficulty concentrating (particularly in older adults), depression, palpitations, dizziness, fainting, and bendopnea [19]. Specific physical signs of heart failure include elevated jugular vein pressure, wet wheezing sounds in the lungs, peripheral edema, hepatojugular reflux, a gallop rhythm, and a laterally displaced apical impulse. Identifying the underlying causes of heart failure is crucial for effective management. For patients with a suspected diagnosis of heart failure, several key investigations are necessary:Electrocardiography (ECG): A normal ECG reduces the likelihood of heart failure.

Transthoracic Echocardiography (TTE): TTE is the primary diagnostic tool used to assess the structural and functional aspects of the heart. During this procedure, various factors are evaluated, including chamber sizes and volumes, left ventricular eccentric or concentric hypertrophy, areas of regional asynergy, global left ventricular systolic function, right ventricular function, pulmonary hypertension, the condition of the valvular apparatus, and left ventricular diastolic dysfunction. Key markers such as increased filling pressure are also examined [20].

Measurement of Natriuretic Peptides (NPs): Evaluating plasma levels of natriuretic peptides is recommended for confirming the diagnosis in the early stages. Elevated levels of B-type natriuretic peptide (BNP) are linked to reduced left ventricular ejection fraction, ventricular hypertrophy, increased filling pressures, and myocardial ischemia [21]. **Basic Screening Tests:** These include serum urea and electrolytes, creatinine levels, a complete blood count (CBC), urinalysis, glycated hemoglobin (HbA1c), lipid profile, and liver and thyroid function tests. These are recommended for all patients with suspected heart failure [13].

In heart failure associated with atrial fibrillation, several hemodynamic changes take place. Intracardiac pressure rises, and cardiac output becomes uneven, both during physical activity and at rest [22, 23].

Left ventricular dysfunction is primarily caused by myocardial damage or stress and is typically a progressive condition. This leads to changes in the geometry and structure of the heart, with ventricular dilation and/or hypertrophy, resulting in the development of a spherical cavity [24].

In these patients, blood flow properties are altered, which is reflected in changes to hemorheological parameters [25]. Patients with reduced left ventricular ejection fraction, along with systolic and diastolic dysfunction, are of particular concern. In this group, several hemorheological factors, such as blood flow, erythrocyte aggregability and deformability, and plasma viscosity, are not well understood, especially in terms of their role in the progression of the disease. It is important to note that blood flow refers to the specific arrangement of erythrocytes within plasma and their movement through blood vessels. Any alterations in the structural characteristics of blood flow result in increased resistance to flow [26]. These changes include an increase in erythrocyte aggregation, a decrease in erythrocyte deformability, and an elevation in local hematocrit levels and plasma viscosity.

The blood supply to any tissue in the body relies on the ability of blood to flow, which is determined by its rheological properties. These rheological parameters are crucial in assessing the adequacy of microcirculation [27]. To evaluate hemorheological characteristics, specifically erythrocyte aggregation, the Index of Erythrocyte Aggregability (IEA) is used. The "Georgian technique," developed by Georgian scientists, is a globally recognized method known for its directness, accuracy, and quantitative precision [28].

The erythrocyte deformability index (IED) [29] is determined using the membrane filtration method. Plasma viscosity (PV) is measured at 37°C using a capillary viscometer, with plasma movement through the capillary being induced by the force of gravity. By identifying these parameters, it becomes possible to assess the microcirculation within capillaries [27]. The microcirculatory bed is a highly organized system, consisting of a blood flow and distribution network (arterioles and pre-capillary sphincters), a metabolic network (capillaries), a depot (post-capillary blood vessels and venules), and a drainage network (lymphatic capillaries and pre-capillaries). Pathology in the microcirculatory bed can involve vascular, intravascular, and extravascular changes [30]. Capillary hydrostatic pressure does not always align with systemic blood pressure and may fluctuate during pathological conditions, independent of changes in blood pressure levels [29]. In such conditions, the primary factor affecting blood flow is the difficulty of blood returning to the heart, which is influenced by the contractile force or mechanical pressure exerted by postcapillary blood vessels—venules and veins. The rheological properties of blood flow play a crucial role in maintaining tissue perfusion within the microcirculatory system [31, 32]. The rheological properties of blood equally influence both systemic (central) hemodynamics and microcirculation. For optimal organ and tissue function, ensuring proper perfusion is essential, which can only be achieved through the normal interaction of hemorheological and hemodynamic factors [33]. It has been established that erythrocyte aggregation and the global contractile function of the cardiac muscle are inversely proportional [34].

This study is particularly relevant in conditions involving atrial fibrillation. However, rheological parameters remain under-researched in patients with ischemic heart failure and other forms of the disease. Hemorheological factors are often overlooked in initial diagnoses, preventive measures, and are rarely considered as a treatment target. Given this, there is a strong interest in assessing rheological parameters in chronic heart failure, as this could allow for more precise management of these critical changes.

In this review, we underscore the importance of assessing hemorheological properties in patients with heart failure to better understand their role in early disease detection. Rheological changes in blood may significantly contribute to disease progression, potentially worsening the patient's condition and advancing the functional class of heart failure. Considering hemorheological parameters as a treatment focus in care planning is essential. Early identification of these changes holds promise in slowing disease progression and may help in preventing severe complications.

**CONCLUSIONS**

This review highlights the importance of assessing hemorheological properties in patients with heart failure, as these parameters may play a critical role in the early detection of the disease. Alterations in rheological factors are likely to contribute to disease progression, potentially worsening the condition and elevating the functional class of heart failure. Integrating hemorheological evaluations into treatment planning could serve as a valuable target to manage heart failure more effectively. Detecting these changes early offers a promising approach to slow disease progression and may even help prevent severe complications.

**REFERENCES:**

1. 2023 Focused Update of the 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure; European Heart Journal (2023) 44, 3627–3639 https://doi.org/10.1093/eurheartj/ehad19
2. Cardiovascular diseases, World health Organization.https://www.who.int/health-topics/cardiovascular-diseases#tab=tab_1)
3. Véronique L. Roger, Epidemiology of Heart Failure, Originally published13 May 2021 https://doi.org/10.1161/CIRCRESAHA.121.318172 Circulation Research. 2021; 128:1421–1434. https://www.ahajournals.org/doi/full/10.1161/CIRCRESAHA.121.318172
4. Smeets M, Vaes B, Mamouris P, Van Den Akker M, at al. Burden of heart failure in Flemish general practices: a registry-based study in the Intego database. BMJ Open 2019; 9: e022972.
5. Gregory Gibson, MD; Vanessa Blumer, MD; Robert John Mentz, MD, FACC; Anuradha (Anu) Lala, MD, FACC Universal Definition and Classification of Heart Failure: A Step in the Right Direction from Failure to Function, Expert Analysis Jul 13, 2021. https://www.acc.org/latest-in-cardiology/articles/2021/07/12/12/31/universal-definition-and-classification-of-heart-failure
6. Tsao CW, Lyass A, Enserro D, Larson MG, at al.Temporal trends in the incidence of and mortality associated with heart failure with preserved and reduced ejection fraction. JACC Heart Fail 2018; 6:678685.
7. 2022 AHA/ACC/HFSA Guideline for the Management of Heart Failure: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. e908 May 3, 2022 Circulation. 2022; 145: e895–e1032. DOI: 10.1161/CIR.0000000000001063
8. Selvaraj S, Claggett B, Pozzi A, et al. Prognostic implications of congestion on physical examination among contemporary patients with heart failure and reduced ejection fraction: PARADIGM-HF. Circulation. 2019; 140:1369– 1379.

9. Hershberger RE, Givertz MM, Ho CY, et al. Genetic evaluation of cardiomyopathy–a Heart Failure Society of America practice guideline. J Card Fail. 2018; 24:281–302.
10. Alexandre J, Cautela J, Ederhy S, et al. Cardiovascular toxicity related to cancer treatment: a pragmatic approach to the American and European Cardio-Oncology Guidelines. J Am Heart Assoc. 2020; 9: e018403.
11. Lund LH, Claggett B, Liu J, Lam CS, Jhund PS, Rosano GM, at al. Heart failure with midrange ejection fraction in CHARM: characteristics, outcomes and effect of candesartan across the entire ejection fraction spectrum. Eur J Heart Fail 2018; 20:12301239.
12. Messroghli DR, Moon JC, Ferreira VM, at al. Clinical recommendations for cardiovascular magnetic resonance mapping of T1, T2, T2 and extracellular volume: a consensus statement by the Society for Cardiovascular Magnetic Resonance (SCMR) endorsed by the European Association for Cardiovascular Imaging (EACVI). J Cardiovasc Magn Reson 2017; 19:75.
13. Theresa A McDonagh, Marco Metra, Marianna Adamo, at al. ESC Scientific Document Group. 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: Developed by the Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC) With the special contribution of the Heart Failure Association (HFA) of the ESC *European Heart Journal*, Volume 42, Issue 36, 21 September 2021, Pages 35993726, https://doi.org/10.1093/eurheartj/ehab368
14. Halperin JL, Levine GN, Al-Khatib SM, et al. Further evolution of the ACC/AHA clinical practice guideline recommendation classification system: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. **Circulation**. 2016; 133:1426–1428.
15. Gregory Gibson, MD; Vanessa Blumer, MD; Robert John Mentz, MD, FACC; Anuradha (Anu) Lala, MD, FACC Universal Definition and Classification of Heart Failure: A Step in the Right Direction from Failure to Function, Expert Analysis Jul 13, 2021.https://www.acc.org/latest-in-cardiology/articles/2021/07/12/12/31/universal-definition-and-classification-of-heart-failure
16. Galderisi M, Cosyns B, Edvardsen T, Cardim N, at al. EACVI Scientific Documents Committee. Standardization of adult transthoracic echocardiography reporting in agreement with recent chamber quantification, diastolic function, and heart valve disease recommendations: an expert consensus document of the European Association of Cardiovascular Imaging. Eur Heart J Cardiovasc Imaging 2017; 18:13011310.
17. Paul A. Heidenreich,Biykem Bozkurt,David Aguilar,Larry A. Allen at al. 2022 AHA/ACC/HFSA Guideline for the Management of Heart Failure: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Originally published1 Apr 2022 https://doi.org/10.1161/CIR.0000000000001063 Circulation. 2022; 145: e895–e1032
18. Bozkurt B, Coats AJS, Tsutsui H, Abdelhamid CM, Adamopoulos S, Albert N, Anker SD, at al…Universal definition and classification of heart failure: a report of the Heart Failure Society of America, Heart Failure Association of the European Society of Cardiology, Japanese Heart Failure Society and Writing Committee of the Universal Definition of Heart Failure: Endorsed by the Canadian Heart Failure Society, Heart Failure Association of India, Cardiac Society of Australia and New Zealand, and Chinese Heart Failure Association. Eur J Heart Fail 2021; 23:352380.
19. Oudejans I, Mosterd A, Bloemen JA, Valk MJ, van Velzen E, Wielders JP, at al. Clinical evaluation of geriatric outpatients with suspected heart failure: value of symptoms, signs, and additional tests. Eur J Heart Fail 2011; 13:51852

20. Lancellotti P, Galderisi M, Edvardsen T, Donal E, Goliasch G, Cardim N, Magne J, Laginha S, at al . Echo-Doppler estimation of left ventricular filling pressure: results of the multicentre EACVI EuroFilling study. Eur Heart J Cardiovasc Imaging 2017; 18:961968.
21. Mueller C, McDonald K, de Boer RA, at al ..Heart Failure Association of the European Society of Cardiology. Heart Failure Association of the European Society of Cardiology practical guidance on the use of natriuretic peptide concentrations. Eur J Heart Fail 2019; 21:715731.
22. Gotsadze M., Kandashvili T., Narsia N., Momtselidze N., Mantskava M. ERYTHROCYTES AGGREGABILITY AND INTRACARDIAC HEMODYNAMICS IN PATIENTS WITH ATRIAL FIBRILLATION. World Science4(76), 2022
23. Gotsadze M., Narsia N., Momtselidze N., Mantskava M. MONITORING HEMORHEOLOGICAL PARAMETERS IN PATIENTS WITH ATRIAL FIBRILLATION (PRIMARY DATES) Georgian Medical News No 5 (290)2019,59-63.
24. Paul A. Heidenreich, Biykem Bozkurt, David Aguilar, at al. 2022 AHA/ACC/HFSA Guideline for the Management of Heart Failure: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines; May 3, 2022 .JACC | Vol. 79 No. 17.
25. *M.Gotsadze, T.Kandashvili, N.Narsia, N.Momtselidze, M.Mantskava, N.Antonova*. **Hemorheological disturbances in patients with chronic form of atrial fibrillation/** Series on Biomechanics, Vol.37, No.2 (2023), 95-102. DOI: 10.7546/SB.10.02.2023
26. M.Mantskava. New and Newest approaches for measurements of blood flow. M.Nauka, 189, p. 2019
27. Mantskava M. Blood Hemorheologycal Status // Lap.Acad. Pub. - ISBN 9783659661112. Saarbrucken. Germany: 2014; 64.
28. Mcedlishvili G., Basic factors determining the hemorheological disorders in the microcirculation. Clin. Hemorheology anf Microcirc., 30(2004)179-180.
29. Titovsky, A.B. Measurement of the deformability of erythrocytes in a stream under the influence of gravitational forces / A.B. Titovsky // Materials of the Intern. Microcirculation conferences. -M.: Yaroslavl, 2019.S. 205-206
30. M.Gotsadze, N. Narsia, N. Momtseldze, M. Mantskava ; Erythrocytes aggregability and blood flow with paroxysmal and persistent forms of atrial fibrillation. Georgia,Tbilisi, Tbilisi State Medical University; Georgia Tbilisi, I. Beritashvili Center of Experimental Biomedicine;Georgia,Tbilisi, St. Lazare Clinic; (ISSN 1512-2689) Journal #69-70
31. Baskurt O. K., Yalcin O., and Meiselman H. J., Hemoreoogy and vascular control mechanisms, Clin. Hemorelogy and Microcirculation 30 (2004) 169-178.
32. Devereux RB, Case DB, Alderman MH, Pickering TG, Chien S, Laragh JH. Possible role of increased blood viscosity in thr hemodynamics of systemic hypertension. Am J Cardiol 2000; 85(10):1265-1268.
33. G.Mchedlishvili Hemorheological changes in microcirculation: their mechanism and measurement technique. Indian J Exp Biol. 2007 Jan;45(1):32-40. Review.
34. Gotsadze M., Momtselidze N., Mantskava M., T.Kandashvili; Rheological Changes During the Atrial Fibrillation. GBMN GEORGIAN BIOMEDICAL NEWS; v.1, ISSUE 1, 2023