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Review article

Prognostic Significance of Structural and Functional Indicators of Myocardial Dysfunction in Postmenopausal Women: Current Perspectives

Gulmira Derbissalina [1], Ayagyoz Umbetzhanova [2], Zhanar Balmukhamedova [3], Natalya Zemlyanskaya [4], Dariga Blyalova [5], Germanas Marinskis [6]

[1] *Head of the Department of General practice with a course of evidence-based medicine, Astana Medical University, Astana, Kazakhstan. E-mail: derbissalina.g@amu.kz*

[2] *Associate Professor of the department of General practice with a course of evidence-based medicine, Astana Medical University, Astana, Kazakhstan. E-mail: umbetzhanova.a@amu.kz*

[3] *Cardiologist, functional diagnostics doctor of the city polyclinic No.6 of the Akimat of Astana, Astana, Kazakhstan. E-mail: balmukhamedova.zhanar@gmail.com*

[4] *Assistant of the Department of General practice with a course of evidence-based medicine, Astana Medical University, Astana, Kazakhstan. E-mail: zemlyanskaya.n@amu.kz*

[5] *Assistant of the Department of Internal Medicine with a course of nephrology, hematology, allergology and immunology, Astana Medical University, Astana, Kazakhstan. E-mail: daka_2015b@gmail.com*

[6] *Professor of the Vilnius University, Institute of Clinical Medicine, Clinic of Cardiovascular Diseases, Vilnius, Lithuania. E-mail: germanas@me.com*

Abstract

Menopause represents a significant period in a woman's life, marked by substantial hormonal changes that significantly impact various bodily systems, particularly the cardiovascular system. The cessation of estrogen production increases the risk of cardiovascular diseases, including myocardial dysfunction. Myocardial dysfunction during menopause may lead to heart failure, particularly in postmenopausal women, where cardiovascular events become more frequent. This condition poses a serious health concern as structural and functional heart changes may remain undetected until advanced stages, complicating diagnosis and treatment. The relevance of studying myocardial dysfunction in menopausal women lies in the profound hormonal and physiological changes occurring during this period. Loss of estrogen's protective effect contributes to increased risks of hypertension, myocardial hypertrophy, and diastolic dysfunction, even with preserved ejection fraction, complicating diagnosis and management.

The pathophysiology of myocardial dysfunction involves endothelial dysfunction, exacerbated by reduced nitric oxide synthesis and lipid metabolism disruptions, further promoting myocardial hypertrophy and fibrosis. Epidemiological data reveal a higher incidence of heart failure with preserved ejection fraction (HFpEF) in postmenopausal women, linked to more pronounced diastolic dysfunction compared to men.

Diagnostic methods like echocardiography and advanced imaging techniques such as MRI play a crucial role in identifying early structural myocardial changes, including left ventricular hypertrophy and fibrosis. Understanding the prognostic significance of these structural and functional myocardial indicators is critical for preventing cardiovascular diseases and improving patient outcomes in menopausal women.

Keywords: *menopause, myocardial dysfunction, cardiovascular disease, estrogen, heart failure, echocardiography, diastolic dysfunction, myocardial hypertrophy.*

Corresponding author: Derbissalina Gulmira, Head of the department of General practice with a course of evidence-based medicine, Astana Medical University, Astana, Kazakhstan
Postal code: Z10K8Y7
Address: Kazakhstan, Astana, Beibitshilik str, 49A
Phone: +77013469331
E-mail: derbissalina.g@amu.kz

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Introduction

Menopause represents a critical phase in a woman's life, characterized by significant hormonal changes that substantially affect various body systems, particularly the cardiovascular system. Following menopause, women lose the protective effects of estrogen, leading to an increased risk of cardiovascular diseases, including myocardial dysfunction. The development of myocardial dysfunction is a precursor to heart failure, which is of particular concern for postmenopausal women, as they experience a rise in cardiovascular events. Myocardial dysfunction during menopause is a serious medical issue with potentially substantial implications for women's health. As menopause begins, women encounter various structural and functional changes in the heart, which can adversely impact prognosis and contribute to the progression of cardiovascular diseases. These changes often go unnoticed until later stages, making diagnosis and management challenging [1,2].

Relevance of the topic. Research on myocardial dysfunction in postmenopausal women is crucial due to the profound hormonal and physiological changes occurring during this period. The loss of estrogen's protective effects significantly increases the risk of developing hypertension, myocardial hypertrophy, and diastolic dysfunction. These changes may occur even with preserved ejection fraction, complicating diagnosis and treatment and necessitating heightened clinical attention [3, 4].

Review objective. The purpose of this review is to systematically analyze and assess the prognostic significance of structural and functional indicators of myocardial dysfunction in postmenopausal women. Emphasis is placed on cardiovascular changes related to hormonal shifts and their role in the development of heart failure. The review also explores diagnostic and predictive methods using modern tools, such as echocardiography, cardiac MRI, and other cardiovascular imaging techniques.

Review methodology

1. **Literature search:** The review is based on a systematic search of scientific literature across databases including PubMed, Scopus, Web of Science, and Google Scholar. Studies were selected based on their relevance to structural and functional myocardial changes in postmenopausal women.

2. **Inclusion criteria:**

-Articles published between 2014 and 2024 to ensure the relevance of data.

-Studies focusing on myocardial dysfunction and cardiovascular risks in postmenopausal women.

-Research including analysis of structural indicators such as left atrial volume index, myocardial mass, left ventricular volumes, and systolic and diastolic function parameters.

3. **Exclusion criteria:**

-Articles published more than 10 years ago.

-Studies unrelated to postmenopausal women.

-Research lacking quantitative or qualitative indicators of structural or functional myocardial changes.

4. **Data analysis:** All selected studies were analyzed for design, methodology, and outcomes. The key focus areas included:

- Evaluation of diastolic function changes.

- Assessment of cardiac volumes and their prognostic significance.

- Impact of hormonal changes on cardiac structure.

- Analysis of prognostic indicators for cardiovascular risks.

5. **Synthesis of results:** The findings from the studies were synthesized to identify the most significant markers of myocardial dysfunction used to predict heart failure in postmenopausal women. Additionally, the review highlights the potential application of modern diagnostic tools in assessing the prognostic value of these markers.

Epidemiology and Pathophysiology of Myocardial Dysfunction

The incidence of cardiovascular diseases in postmenopausal women significantly increases. Research shows that women in this period have a higher risk of both systolic and diastolic myocardial dysfunction. This is associated with hormonal imbalances affecting vascular tone, lipid metabolism, and inflammatory processes, leading to impaired cardiac function [5,6]. The menopausal period is characterized by a sharp decline in estrogen levels, which impacts the cardiovascular system. Estrogens have a cardioprotective effect by improving endothelial function, increasing antioxidant levels, and reducing inflammatory processes. The loss of this protective effect contributes to increased vascular stiffness, elevated blood pressure, and atherogenesis. One of the key mechanisms underlying myocardial dysfunction in the postmenopausal period is endothelial dysfunction. Decreased estrogen levels lead to reduced nitric oxide synthesis, impairing vascular relaxation and promoting vasoconstriction. This increases myocardial workload and contributes to the development of left ventricular hypertrophy, an early manifestation of myocardial structural changes [5].

Estrogens also influence lipid and carbohydrate metabolism, maintaining a favorable lipid profile in premenopausal women. After menopause, there is an increase in total cholesterol and low-density lipoprotein levels, which contributes to atherogenic changes in the vessels and exacerbates cardiovascular risks [6]. These changes can lead to increased myocardial mass, development of fibrosis, and impaired cardiac contractility. Studies show that postmenopausal women have a significantly higher incidence of heart failure with preserved ejection fraction compared to men. This is due to more pronounced diastolic dysfunction, highlighting the importance of timely diagnosis of diastolic dysfunction and structural changes in the myocardium [7].

An important aspect of the pathogenesis of heart disease in menopausal women is also the activation of the renin-angiotensin-aldosterone system, leading to sodium and water retention, increased vascular stiffness, and myocardial hypertrophy. These factors also increase the risk of cardiovascular events [8].

During menopause, decreased estrogen levels directly affect the cardiovascular system, leading to changes in endothelial function and increased vascular stiffness.

These changes result in impaired diastolic function of the left ventricle, which can lead to heart failure with preserved ejection fraction.

Diastolic dysfunction may not manifest until it reaches clinically significant levels, complicating early-stage diagnosis [7, 8].

Structural changes in the myocardium and diagnostic methods for assessment

Structural changes in the myocardium in menopausal women include myocardial hypertrophy, increased wall thickness, and fibrosis. Myocardial hypertrophy is an early sign of increased cardiac workload caused by elevated blood pressure and changes in vascular tone resulting from the loss of estrogenic protection [9]. These changes are particularly pronounced in women with hypertension and obesity, confirming their prognostic significance in the development of heart failure [10]. Structural and functional changes in the myocardium play a crucial role in the progression of heart failure. Assessing these changes is an important prognostic indicator for identifying cardiovascular complications in postmenopausal women. Recent studies focus on the relationship between structural-functional indicators and cardiovascular disease prognosis, emphasizing the importance of early diagnosis and timely intervention. Structural changes in the myocardium, such as left ventricular hypertrophy, enlargement of the left atrium, and increased myocardial mass, may contribute to the development of myocardial fibrosis and impaired myocardial function. These changes have significant prognostic value as they may precede clinical manifestations of cardiovascular disease in postmenopausal women. For example, left ventricular hypertrophy and left atrial enlargement are often associated with an increased risk of heart failure and arrhythmias [9, 10].

The menopausal period is characterized by a sharp decline in estrogen levels, affecting the cardiovascular system. Estrogens have a cardioprotective effect by improving endothelial function, increasing antioxidant levels, and reducing inflammatory processes. The loss of this protective effect contributes to increased vascular stiffness, elevated blood pressure, and atherogenesis [9].

One of the key mechanisms underlying myocardial dysfunction in the postmenopausal period is endothelial dysfunction. Decreased estrogen levels lead to reduced nitric oxide synthesis, impairing vascular relaxation and promoting vasoconstriction. This increases myocardial workload and contributes to left ventricular hypertrophy, an early manifestation of myocardial structural changes [10]. Estrogens also influence lipid and carbohydrate metabolism, maintaining a favorable lipid profile in premenopausal women. After menopause, there is an increase in total cholesterol and low-density lipoprotein levels, which contributes to atherogenic changes in the vessels and exacerbates cardiovascular risks [10]. These changes can lead to increased myocardial mass, development of fibrosis, and impaired cardiac contractility. Studies show that postmenopausal women have a significantly higher incidence of heart failure with preserved ejection fraction compared to men. This is due to more pronounced diastolic dysfunction, highlighting the importance of timely diagnosis of diastolic dysfunction and structural changes in the myocardium [9]. An important aspect of the pathogenesis of heart disease in menopausal women is also the activation of the renin-angiotensin-aldosterone system, leading to sodium and water retention, increased vascular stiffness, and myocardial hypertrophy. These factors also increase the risk of cardiovascular events [8].

Understanding the prognostic significance of structural and functional myocardial changes in postmenopausal women is critical for preventing cardiovascular diseases and improving patient quality of life.

Functional indicators of myocardial dysfunction

Functional changes in the myocardium in postmenopausal women are most often expressed as diastolic dysfunction, although systolic function issues may also arise. Diastolic dysfunction is a condition where the heart loses its ability to fully relax between contractions, leading to increased pressure in the chambers and reduced capacity to fill with blood effectively [15]. Assessment of diastolic function is traditionally performed using Doppler echocardiography, which allows for the measurement of early and late diastolic filling velocities of the left ventricle. This method can also be used to assess left ventricular filling pressures, which are key prognostic indicators [16].

Other functional changes, such as reduced global longitudinal strain (GLS), can be detected using tissue Doppler imaging and speckle tracking techniques. These methods allow for the assessment of subtle changes in myocardial deformation that may precede clinically significant impairments in cardiac contractility [17]. Studies show that reduced GLS correlates with an increased risk of cardiovascular complications and worsened prognosis in menopausal women [18].

It is also important to note that preserved ejection fraction does not always indicate the absence of cardiac dysfunction. A significant number of menopausal women develop heart failure with preserved ejection fraction (HFpEF), characterized by normal systolic function with significant diastolic dysfunction [19]. HFpEF is more common in older women and is closely associated with hypertension, obesity, and diabetes, highlighting the importance of a comprehensive assessment of both structural and functional changes for predicting cardiovascular outcomes.

Structural and functional changes in the myocardium in menopausal women are closely interrelated and significantly impact cardiovascular disease prediction. Early detection of these changes using modern imaging techniques and functional tests is crucial for preventing and managing heart failure in this patient group.

Diagnostic methods for assessing myocardial dysfunction

The role of echocardiography and other imaging methods. Echocardiography (Echo) is the primary imaging method for diagnosing and monitoring myocardial dysfunction. It allows for the assessment of both structural and functional changes in the heart, such as myocardial hypertrophy, chamber enlargement, valve dysfunction, and diastolic dysfunction [11, 12].

Additional imaging methods, such as cardiac magnetic resonance imaging (MRI) and computed tomography (CT), provide more detailed information

about the structure and function of the myocardium. These methods are especially useful for evaluating myocardial fibrosis, chamber sizes, and cardiac function. MRI allows for more accurate visualization of the myocardium and its changes, which can be crucial in complex clinical cases where standard imaging methods do not provide a complete picture of the patient's condition [13,14].

Evaluation of functional parameters. Functional assessment of the myocardium includes measuring ejection fraction (EF), end-diastolic volume (EDV), end-systolic volume (ESV), as well as other parameters such as cardiac output (CO) and stroke volume (SV) [15,16]. These indicators are essential for determining the degree of heart failure and assessing the impact of structural changes on cardiac function. Functional evaluation also includes analysis of diastolic function parameters, such as e' (tissue Doppler relaxation velocity) and the E/e' ratio (the ratio of peak early diastolic filling to tissue relaxation velocity). These parameters are important for diagnosing diastolic dysfunction, which may be present even with preserved EF [17, 18].

Prognostic significance of structural indicators. Structural changes in the myocardium, such as left ventricular hypertrophy (LVH), left atrial enlargement (LAE), and increased myocardial mass, have prognostic significance for assessing the risk of cardiovascular events. LVH and LAE are often associated with worsening cardiac function and an increased risk of heart failure and arrhythmias [19, 20]. Indexed left atrial volume (LAVi) and left ventricular myocardial mass (LVMi) are key indicators that can help assess prognosis in menopausal women. These parameters can predict not only current functional impairments but also the risk of further deterioration and development of cardiovascular diseases [21, 22].

Prognostic indices and parameters. Key indices and parameters associated with prognosis include end-diastolic volume (EDV), end-systolic volume (ESV), myocardial mass, left atrial volume, and diastolic function parameters [23, 24]. These measures assist in determining the risk level and planning therapeutic interventions. For more precise prognosis, parameters such as the E/e' ratio and tissue Doppler relaxation velocity are also considered. Elevated values of these parameters can indicate significant diastolic dysfunction, which may require attention and possible adjustment of the therapeutic strategy [25, 26].

Assessment of diastolic and systolic function parameters. Functional parameters such as ejection fraction (EF), end-diastolic volume (EDV), end-systolic volume (ESV), stroke volume (SV), and cardiac output (CO) are crucial for evaluating myocardial condition and the extent of heart failure [27,28]. EF is used to assess systolic function of the heart, while EDV and ESV help evaluate volume changes associated with heart failure [29,30]. Diastolic function parameters, such as e' (tissue Doppler relaxation velocity) and the E/e' ratio (the ratio of peak early diastolic filling to tissue relaxation velocity), help assess diastolic dysfunction, which can be present even with preserved EF [31,32]. These indicators are particularly important for diagnosing early stages of heart failure and planning further treatment.

Early diagnosis and prognostic strategies. Early diagnosis of myocardial dysfunction is a key factor in reducing the risk of cardiovascular diseases in postmenopausal women. Modern diagnostic methods allow for the detection of structural and functional changes at early stages, enabling timely intervention and prognosis adjustment. One of the most informative diagnostic methods is echocardiography. Three-dimensional echocardiography provides more accurate data on myocardial morphology and function compared to traditional two-dimensional echocardiography. Technologies such as speckle tracking and tissue Doppler imaging allow for the assessment of myocardial deformation and detection of early signs of heart failure, even with normal ejection fraction [20]. This method is particularly important for identifying subclinical forms of dysfunction in women who do not exhibit obvious symptoms of heart disease [21]. Stress echocardiography is also a valuable diagnostic tool for evaluating myocardial response to physical exertion. It helps uncover latent ischemia and assess cardiac functional reserves, which is crucial for women at high risk of ischemic heart disease [22]. In addition to imaging methods, biomarkers play a significant role in early diagnosis. Natriuretic peptides (BNP and NT-proBNP) are markers of cardiac stress and are used to assess heart failure risk. Elevated levels of these peptides in menopausal women may indicate hidden myocardial dysfunction and increased risk of cardiac complications [23].

The use of a combination of imaging methods and biomarker analysis allows for a comprehensive approach to diagnosis and improves prognosis for women with early signs of myocardial dysfunction during menopause.

Clinical significance and prognostic optimization

Clinical significance of structural and functional changes. Effective assessment of functional parameters not only aids in diagnosing heart failure but also in predicting its progression. Understanding the significance of parameters such as e' and E/e' can help in the early detection of diastolic dysfunction and improve patient prognosis [33,34]. The clinical significance of structural and functional myocardial changes in postmenopausal women lies in their ability to predict cardiovascular outcomes. Research indicates that structural changes, such as left ventricular hypertrophy and myocardial fibrosis, are closely associated with an increased risk of heart failure, arrhythmias, and sudden cardiac death [24]. Diastolic dysfunction is the most common functional change in menopausal women and serves as an early indicator of heart failure with preserved ejection fraction. Women with pronounced diastolic dysfunction face significantly higher risks of hospitalization due to heart failure and increased mortality [25]. Additionally, changes in myocardial deformation, such as decreased global longitudinal strain (GLS), are potent prognostic markers. Women with reduced GLS have poorer outcomes, even when other cardiac function parameters remain normal. This underscores the importance of incorporating advanced technologies for assessing myocardial deformation in clinical practice [26]. Early diagnosis and active monitoring of structural and functional myocardial changes allow for the development of individualized treatment strategies aimed at slowing the progression of heart failure and improving the quality of life for menopausal women.

Potential strategies for prognostic improvement. To optimize prognosis in patients with myocardial dysfunction, a comprehensive approach is recommended, including regular monitoring of functional parameters and the application of therapeutic strategies to correct identified abnormalities [35,36]. For instance,

medications such as ACE inhibitors, beta-blockers, and aldosterone antagonists can improve both diastolic and systolic myocardial function [37,38]. Non-pharmacological interventions, such as lifestyle modifications, stress reduction, and physical activity, also play a crucial role in managing and predicting cardiovascular diseases [39].

Conclusions

The menopause period is a critical phase in a woman's life, marked by significant changes in the cardiovascular system. The loss of estrogen protection leads to numerous adverse effects on the myocardium, including structural changes such as hypertrophy and fibrosis, and functional impairments such as diastolic dysfunction and reduced cardiac contractility. These changes play a key role in increasing the risk of cardiovascular diseases and mortality in postmenopausal women. Early diagnosis of structural and functional myocardial changes, based on modern imaging methods and biomarker utilization, is a crucial step in preventing heart failure. It is important to note that subclinical forms of myocardial dysfunction often remain undetected with standard diagnostic approaches, highlighting the need for more sensitive methods, such as speckle tracking and tissue Doppler imaging.

The prognostic significance of these changes has already been demonstrated in several studies, indicating the need for active monitoring of menopausal women to identify early signs of cardiac abnormalities. This will help improve outcomes and prevent severe cardiovascular complications. This review emphasizes the importance of a comprehensive approach to the diagnosis and treatment of cardiovascular diseases in menopausal women. If needed, I can gather specific references for each section and prepare final text revisions.

Based on the literature analysis, the following conclusions can be drawn:

1. Effective assessment of both systolic and diastolic myocardial function is essential for accurate diagnosis and prognosis of cardiovascular diseases, especially in menopausal women [26, 27, 30].

2. Parameters such as e', E/e', LVEDV, and LVESV play a key role in predicting the risk of heart failure and other cardiovascular conditions [31, 32].

3. A comprehensive approach, including both pharmacological and non-pharmacological treatment, is important for improving prognosis and quality of life for patients [34, 35].

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Дербисалина Г.А. [1], Умбетжанова А.Т. [2], Бальмухамедова Ж.А. [3], Землянская Н.С. [4], Блялова Д.Б. [5], Germanas Marinskis [6]

[1] Дәлелді медицина курсы бар жалпы дәрігерлік практика кафедрасының меңгерушісі, Астана медицина университеті, Астана, Қазақстан. E-mail: derbissalina.g@amu.kz

[2] Дәлелді медицина курсымен жалпы дәрігерлік практика кафедрасының доценті, Астана медицина университеті, Астана, Қазақстан. E-mail: umbetzhanova.a@amu.kz

[3] Астана қаласы әкімдігінің №6 қалалық емханасының кардиологы, функционалдық диагностика дәрігері, Астана, Қазақстан. E-mail: balmukhamedova.zhanar@gmail.com

[4] Дәлелді медицина курсымен жалпы дәрігерлік практика кафедрасының ассистенті, Астана медицина университеті, Астана, Қазақстан. E-mail: zemlyanskaya.n@amu.kz

[5] Нефрология, гематология, аллергология және иммунология курсы бар ішкі аурулар кафедрасының ассистенті, Астана медицина университеті, Астана, Қазақстан. E-mail: daka_2015b@gmail.com

[6] Вильнюс университетінің профессоры, Клиникалық медицина институты, Жүрек-қан тамырлары аурулары клиникасы, Вильнюс, Литва. E-mail: germanas@me.com

Түйіндеме

Менопауза - маңызды гормоналды және физиологиялық өзгерістермен сипатталатын әйел өміріндегі маңызды өтпелі кезең. Бұл өзгерістер дененің әртүрлі жүйелеріне, соның ішінде жүрек-тамыр жүйесіне әсер етеді. Менопаузадан кейінгі кезеңде эстрогендердің қорғаныш әсерін жоғалту жүрек-тамыр ауруларының, соның ішінде миокард дисфункциясының даму қаупінің жоғарылауына әкеледі. Менопаузадағы әйелдердегі миокард дисфункциясы жүректің құрылымдық және функционалдық өзгерістерімен көрінеді, мысалы, сол жақ қарыншаның гипертрофиясы, фиброз және диастолалық функцияның бұзылуы.

Бұл өзгерістер көбінесе соңғы кезеңдерге дейін анықталмай диагнозды қиындатады және сақталған шығару фракциясымен жүрек жеткіліксіздігінің қаупін арттырады.

Миокард дисфункциясының негізінде жатқан патофизиологиялық механизмдерге эндотелий дисфункциясы, ренин-ангиотензин-альдостерон жүйесінің активтенуі, липидтер мен көмірсулар алмасуының өзгеруі жатады. Бұл факторлар қан тамырларының қаттылығына және қан қысымының жоғарылауына ықпал етеді. Бұл өз кезегінде миокардқа жүктемені арттырады және жүрек жеткіліксіздігінің өршуіне ықпал етеді. Миокард дисфункциясын диагностикалаудың маңызды аспектісі эхокардиография, магнитті-резонансты бейнелеу және компьютерлік томография сияқты бейнелеу әдістері болып табылады. Бұл әдістер миокардтың құрылымдық және функционалдық өзгерістерін бағалауға мүмкіндік береді, бұл постменопаузадағы әйелдерде жүрек-қан тамырлары қаупін ерте анықтау үшін маңызды.

Менопаузадағы әйелдердегі миокардтың құрылымдық және функционалдық өзгерістерінің болжамдық маңыздылығын түсіну жүрек-қан тамырлары ауруларының алдын алу және пациенттердің өмір сүру сапасын жақсартудың кілті болып табылады. Заманауи диагностикалық әдістер мен ерте араласу постменопаузадағы жүрек-қан тамырлары өзгерістерінің жағымсыз салдарын азайтуға көмектеседі.

Түйін сөздер: менопауза, миокард дисфункциясы, жүрек-тамыр аурулары, эстроген, жүрек жеткіліксіздігі, эхокардиография, диастолалық дисфункция, миокард гипертрофиясы.

Прогностическая значимость структурно-функциональных показателей дисфункции миокарда у женщин в менопаузальном периоде: Современное состояние проблемы

Дербисалина Г.А. [1], Умбетжанова А.Т. [2], Бальмухамедова Ж.А. [3], Землянская Н.С. [4], Блялова Д.Б. [5], Germanas Marinskis [6]

[1] Заведующая кафедрой общей врачебной практики с курсом доказательной медицины, Медицинский университет Астана, Астана, Казахстан. E-mail: derbissalina.g@amu.kz

[2] Доцент кафедры общей врачебной практики с курсом доказательной медицины, Медицинский университет Астана, Астана, Казахстан. E-mail: umbetzhanova.a@amu.kz

[3] Врач-кардиолог, врач функциональной диагностики городской поликлиники №6 Акимата города Астаны, Казахстан. E-mail: balmukhamedova.zhanar@gmail.com

[4] Ассистент кафедры общей врачебной практики с курсом доказательной медицины, Медицинский университет Астана, Астана, Казахстан. E-mail: zemlyanskaya.n@amu.kz

[5] Ассистент кафедры внутренних болезней с курсом нефрологии, гематологии, аллергологии и иммунологии, Медицинский университет Астана, Астана, Казахстан. E-mail: daka_2015b@gmail.com

[6] Профессор Вильнюсского университета, Институт клинической медицины, Клиника сердечно-сосудистых заболеваний, Вильнюс, Литва. E-mail: germanas@me.com

Резюме

Менопауза представляет собой важный переходный период в жизни женщины, который характеризуется значительными гормональными и физиологическими изменениями. Эти изменения оказывают влияние на различные системы организма, включая сердечно-сосудистую систему. В постменопаузальном периоде потеря защитного эффекта эстрогенов приводит к повышению риска развития сердечно-сосудистых заболеваний, в том числе дисфункции миокарда. Дисфункция миокарда у женщин в менопаузе проявляется как структурными, так и функциональными изменениями сердца, такими как гипертрофия левого желудочка, фиброз и нарушение диастолической функции. Эти изменения часто остаются незамеченными до поздних стадий, что усложняет диагностику и увеличивает риск сердечной недостаточности с сохраненной фракцией выброса.

Патофизиологические механизмы, лежащие в основе миокардиальной дисфункции, включают эндотелиальную дисфункцию, активацию ренин-ангиотензин-альдостероновой системы, а также изменения липидного и углеводного обмена. Эти факторы способствуют жесткости сосудов и повышению артериального давления, что увеличивает нагрузку на миокард и способствует прогрессированию сердечной недостаточности. Важным аспектом в диагностике миокардиальной дисфункции являются методы визуализации, такие как эхокардиография, магнитно-резонансная томография и компьютерная томография. Эти методы позволяют оценить структурные и функциональные изменения в миокарде, что важно для раннего выявления сердечно-сосудистых рисков у женщин в постменопаузе.

Понимание прогностической значимости структурных и функциональных изменений миокарда у женщин в менопаузе имеет ключевое значение для предотвращения сердечно-сосудистых заболеваний и улучшения качества жизни пациенток. Современные методы диагностики и раннего вмешательства могут помочь минимизировать негативные последствия сердечно-сосудистых изменений в постменопаузальном периоде.

Ключевые слова: менопауза, дисфункция миокарда, сердечно-сосудистые заболевания, эстроген, сердечная недостаточность, эхокардиография, диастолическая дисфункция, гипертрофия миокарда.