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REVIEW ARTICLE

MILITARY AEROMEDICAL EVALUATION IN CARDIOMYOPATHIES AND HEART FAILURE: A REVIEW OF CURRENT GUIDELINES

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Introduction: Cardiomyopathies and heart failure are conditions of diverse etiology and clinical course, posing a significant challenge within the aviation population due to the risk of sudden cardiac events. The aim of this paper was to present the current state of knowledge on these diseases in the context of military aeromedical evaluation.

Methods: This is a review article based on an analysis of scientific publications from the PubMed and Google Scholar databases. The study takes into account the guidelines of the European Society of Cardiology, NATO recommendations, and regulations applied in the air forces of various countries.

Results: The main phenotypes of cardiomyopathies and heart failure were discussed in the context of their clinical and aeromedical relevance among military pilots. Diagnostic criteria were presented, along with the differentiation between pathological changes and physiological training adaptations, as well as the role of modern diagnostic tools such as imaging and genetics.

Discussion and Conclusions: Although cardiomyopathies and heart failure are rare among military pilots, they are associated with the risk of sudden events and constitute a significant limitation in flight clearance. Advancements in imaging diagnostics, genetics, and risk assessment now allow for a more individualized approach to aeromedical certification, particularly in cases of mild cardiomyopathy phenotypes. An increasing body of evidence suggests that selected pilots diagnosed with myocardial disease, in the absence of high-risk features, may safely continue duties within a limited scope. However, this requires strict selection criteria, regular clinical monitoring, and ongoing research into operational safety within this professional group.

Keywords: cardiomyopathies, heart failure, military medicine, aviation medicine, risk assessment, medical certification

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INTRODUCTION

Aviation personnel, and military pilots in particular, are exposed to specific environmental factors inherent to the aviation setting, such as hypoxia, hypobaria, gravitational forces (G-forces), and positive pressure breathing. All of these elements place a significant strain on the cardiovascular system and may contribute to the manifestation or progression of previously undiagnosed myocardial diseases [7]. In the context of performing operational duties in flight, particular attention must be given to heart conditions associated with the risk of syncope, sudden cardiac death (SCD), arrhythmias, or heart failure.

Cardiomyopathies are a heterogeneous group of myocardial diseases with variable morphological, functional, and clinical presentations, often characterized by an unpredictable course. They are defined as conditions in which structural and/or functional abnormalities of the myocardium are present that cannot be explained by other diseases (e.g., significant coronary artery disease, valvular heart disease, congenital heart disease or arterial hypertension) that could account for the observed dysfunction [2]. The current classification by the European Society of Cardiology (ESC) identifies five main phenotypes of cardiomyopathy: hypertrophic cardiomyopathy (HCM), dilated cardiomyopathy (DCM), restrictive cardiomyopathy (RCM), arrhythmogenic right ventricular cardiomyopathy (ARVC), and non-dilated left ventricular cardiomyopathy (NDLVC) [2].

Heart failure (HF) is also a significant health issue in the pilot population. It is defined as a clinical syndrome resulting from structural or functional myocardial abnormalities. Typical symptoms of HF include dyspnea, peripheral edema, fatigue, and signs of congestion in the pulmonary and/or systemic circulation. The prevalence of HF in the general population is estimated at 1–2%, with a marked increase with age [9]. In the population of military pilots—due to rigorous medical screening and age restrictions—HF occurs less frequently. Nevertheless, subclinical or borderline cases may present substantial challenges in aeromedical evaluation [13].

In Poland, fitness for military service, including service in the air, is currently regulated by the Ordinance of the Minister of National Defence dated March 25, 2024 [14]. Paragraph 38 of this legal act contains provisions related to myocardial diseases, including cardiomyopathies and heart failure, defining criteria for assessing the suitability of candidates for service under aviation conditions (Tab. 1).

The aim of this article is to review selected myocardial diseases—with particular focus on cardiomyopathies and heart failure—in the context of their clinical significance and impact on the ability to perform military aviation duties. The discussion includes the latest diagnostic recommendations, epidemiological data, and key regulatory aspects relevant to the medical assessment of military pilots.

METHODS

A comprehensive literature review was conducted using electronic databases such as PubMed® and Google Scholar, with a focus on cardiomyopathy and heart failure, particularly within military populations between 2000 and 2025. The search included keywords such as: “cardiomyopathies,” “heart failure,” “military medicine,” “aerospace medicine,” and “risk assessment.” Relevant studies addressing myocardial diseases in the context of military medical evaluation were included. Additionally, the latest clinical guidelines issued by aviation medicine regulatory authorities were reviewed to provide context for the management of cardiomyopathies and heart failure in military aviation service.

Tab. 1. Ordinance of the Minister of National Defence of March 25, 2024, on the evaluation of fitness for military service and the procedures of military medical boards in these matters, Annex No. 2 I – List of diseases and defects considered in the evaluation of fitness for military service in aviation, ground flight support, and aviation engineering services, and the conditions for issuing decisions in these cases. Chapter X – Cardiovascular system

Paragraph 38, point 1	I A	I B	I C
Myocardial diseases or recurrent or permanent arrhythmias that do not impair overall fitness:	Fit / Unfit (Z/N)	Fit / Unfit (Z/N)	Fit / Unfit (Z/N)
Paragraph 38, point 2 2			
Myocardial diseases or recurrent or permanent arrhythmias that impair overall fitness:	Unfit (N)	Unfit (N)	Unfit (N)

Cardiomyopathies and Heart Failure in Aviation: Current Knowledge and Diagnostic Pathways

Introduction

The issue of cardiomyopathies and HF in the context of military aviation remains poorly documented, with available literature limited and often restricted to single case reports. One of the few comprehensive studies is the 2019 NATO Cardiology Working Group document, published in the Heart journal [4]. There is a lack of systematic reports regarding the incidence of cardiomyopathies among armed forces aviation personnel, and the topic is also marginally addressed in American military aviation guidelines (US Waiver Guide) [1].

Diagnosis of Cardiomyopathies in Military Aviation

Electrocardiography (ECG)

ECG remains the primary screening tool for detecting cardiovascular abnormalities, both during initial qualification for service and in routine examinations of pilots. Although a resting 12-lead ECG may appear normal in a small proportion of cardiomyopathy patients, abnormalities are frequently present across all subtypes and may precede clinical phenotype development by many years [2]. Due to the limited sensitivity and specificity of this method, every military pilot should undergo at least one echocardiographic examination in their lifetime.

Transthoracic Echocardiography (TTE)

Echocardiography remains the most commonly used non-invasive cardiac imaging method, offering high diagnostic sensitivity and broad availability. However, its accuracy depends on the operator's experience and the quality of the equipment used. TTE provides information on the valvular structure and function, the left and right ventricles, the presence of dynamic outflow tract obstruction, pulmonary hypertension, or pericardial effusion. In Poland, this examination is routinely performed in candidates for the Military Aviation Academy (LAW), while in later professional stages, it is performed mainly upon clinical indication. The most common indications include: dyspnea, chest pain, palpitations, fainting, syncope, presence of a heart murmur, signs of heart failure on physical examination, or a family history of SCD or cardiomyopathy [2].

Other Diagnostic Methods

In cases requiring in-depth evaluation, advanced imaging techniques are used: cardiac magnetic resonance (CMR), computed tomography (CT), and nuclear medicine techniques (PET, scintigraphy). CMR is currently the method of choice in the diagnosis of cardiomyopathies. Thanks to its high spatial resolution and excellent tissue characterization, CMR enables precise assessment of cardiac function and structure as well as differentiation of pathological changes from physiological exercise-induced adaptations. This examination plays a critical role, e.g., in SCD risk stratification in patients with hypertrophic cardiomyopathy, and in the management of patients with Fabry disease or iron overload syndromes. The combination of cine imaging, late gadolinium enhancement (LGE), and mapping techniques allows for accurate characterization of most inherited forms of cardiomyopathy [6]. Endomyocardial biopsy (EMB), while remaining the gold standard in the diagnosis of myocarditis, is reserved for selected cases due to its invasive nature and risk of complications. Genetic testing is playing an increasingly important role in the diagnostic process, allowing for diagnostic confirmation, prognostic assessment, and personalized treatment planning [2].

Screening and Family Surveillance

According to current guidelines, individuals without a detected clinical phenotype of cardiomyopathy and without a positive family history may be exempted from further follow-up, with a recommendation for re-evaluation should symptoms or new clinical data arise. Due to the incomplete genetic penetrance of cardiomyopathies (70–90% by age 70), periodic screening examinations (ECG, TTE) are recommended for carriers of pathogenic variants and family members affected by the disease. The frequency of screening before age 60 should be every 1–3 years, and after age 60 every 3–5 years [2].

Adjustment of Medical Certification According to the Pilot's Career Stage

Because of the possibility of late-onset cardiomyopathy, the diagnostic and medical certification approach should vary depending on the stage of the pilot's career. For candidates entering service, a diagnosis of cardiomyopathy is a contraindication to qualification. For active professional pilots, decisions should be individualized and based on a comprehensive assessment of cardiovascular event risk.

Cardiomyopathies in the Context of Aviation Medical Certification

Hypertrophic Cardiomyopathy (HCM)

Hypertrophic cardiomyopathy (HCM) is the most common genetically determined heart muscle disease, occurring in approximately 1 in 500 individuals in the general population [11]. It is inherited in an autosomal dominant manner in nearly half of patients. For a long time, HCM may be asymptomatic, while clinically overt forms manifest with symptoms such as dyspnea, chest pain, dizziness, presyncope, and syncope. HCM is also one of the leading causes of SCD in young athletes, with an estimated annual mortality risk of 1–2% [3,5].

Basic screening includes ECG, although about 10% of patients may have a normal result [11]. The gold standard diagnostic method is TTE. The diagnostic criterion is a left ventricular wall thickness ≥15 mm in any segment. In individuals with a positive family history, confirmed pathogenic variant, or characteristic ECG changes, the threshold is lowered to 13 mm [2].

In the qualification of candidates to the LAW, a diagnostic challenge may be presented by the so-called "athlete's heart" — an adaptive hypertrophy of the myocardium due to prolonged physical exercise. Physiological wall thickening rarely exceeds 12 mm and is usually not accompanied by other echocardiographic abnormalities such as diastolic dysfunction. In doubtful cases, CMR may be useful [3,11].

According to the latest data, moderate physical activity may be safe and even beneficial for patients with HCM [2]. In carefully selected individuals with mild myocardial hypertrophy and low risk of sudden cardiac events, undertaking intensive physical activity, including competitive sports, is also possible [2]. These findings may provide grounds for individual consideration of positive medical certification for experienced pilots diagnosed with HCM.

Currently used diagnostic procedures for candidates to the LAW — including ECG and TTE — allow for a high probability exclusion of HCM during the qualification process for military pilot training.

Dilated Cardiomyopathy (DCM) and Non-Dilated Left Ventricular Cardiomyopathy (NDLVC)

DCM is characterized by enlargement of the heart chambers, especially the left ventricle, and impaired systolic function. Diagnosis is based on echocardiographic criteria: left ventricular end-diastolic diameter (LVEDD) >58 mm in men and >52 mm in women, left ventricular end-diastolic volume index (LVEDV) ≥75 ml/m² in men and ≥62 ml/m² in women, and left ventricular ejection fraction (LVEF) <50% [11]. NDLVC is a form of cardiomyopathy of non-ischemic etiology without left ventricular dilation. Ejection fraction may be normal or reduced, and the imaging may show scarring or focal contractility abnormalities [2].

The etiology of DCM can be both genetic and acquired — including toxins (alcohol, cocaine), hormonal disorders, arrhythmias, or viral infections. Myocarditis, common in young adults, can lead to transient or permanent heart failure. In half of patients, changes resolve spontaneously; however, in 25%, chronic left ventricular dysfunction develops.

ECG changes in DCM are less characteristic than in HCM, and TTE remains the primary diagnostic method. In secondary cases, regression of changes and full recovery are possible.

Routine TTE performed during the qualification process for the LAW effectively detects DCM. In borderline cases, especially in individuals with a positive family history, periodic monitoring (every 5 years until age 50) is recommended; in military pilots, even more frequent follow-up is advised [4,8].

Asymptomatic individuals and those with mild forms of DCM or NDLVC may be permitted to engage in most competitive sports, provided there is only minor impairment of left ventricular function, and after exclusion of exercise-induced arrhythmias and significant myocardial fibrosis [2]. Similar to HCM, in phenotypically mild cases of DCM and NDLVC, consideration may be given to allowing military pilots to continue flying service under restrictions.

Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC)

ARVC is a rare disease (1:2000–1:5000) characterized by progressive replacement of cardiomyocytes with adipose and fibrous tissue. This leads to arrhythmias and right ventricular failure. The disease predominantly affects men aged 20–40 years [11].

Clinical symptoms include palpitations, dizziness, syncope and SCD. Diagnostics include clinical assessment, ECG (epsilon wave, T-wave inversions in V1–V3), TTE and CMR. The high diagnostic value of CMR lies in its ability to detect structural abnormalities.

ARVC is a recognized cause of SCD during physical exertion. For this reason, it constitutes an absolute contraindication to competitive sports participation [12].

Restrictive Cardiomyopathy (RCM)

RCM is the rarest and most poorly prognosed phenotype of cardiomyopathy, diagnosed primarily through TTE. Prognosis is unfavorable — the leading cause of death is heart failure (over 40% of cases), and the 5-year survival rate in adult patients does not exceed 50% [2].

Heart Failure (HF) in the Aviation Population

Heart failure is a syndrome of symptoms (dyspnea, edema, reduced exercise tolerance) resulting from abnormal cardiac structure or function. Its prevalence increases with age — from 1% in individuals under 55 to over 10% in those older than 70. The prognosis is serious — 5-year mortality ranges from 53% to 67% [9].

Diagnosis of HF requires both symptom confirmation and evidence of left ventricular dysfunction:

- heart failure with reduced ejection fraction (HFrEF): LVEF ≤40%,
- heart failure with mildly reduced ejection fraction (HFmrEF): LVEF 41–49%,
- heart failure with preserved ejection fraction (HFpEF): LVEF ≥50% along with HF symptoms, diastolic dysfunction, and elevated BNP/NT-proBNP levels.

Due to its age association, HF is of particular relevance among older military pilots [13]. Effective management of underlying conditions contributing to HF — such as hypertension, arrhythmias, and coronary artery disease — is key to prevention.

Modern HF therapies and improved risk stratification now allow selected patients to safely participate in moderate physical activity. In individuals without exercise-induced arrhythmias and with well-controlled HFmrEF or HFpEF, participation in certain sports disciplines is possible — after prior completion of a maximal exercise test, preferably cardiopulmonary exercise testing (CPET) [10].

Management of Pilots Diagnosed with Cardiomyopathy

In the context of military aviation, HF and cardiomyopathies hold particular importance due to their impact on tolerance to G-forces and hypoxia. Positive G-forces (+Gz) can induce arrhythmias and increase the risk of SCD, especially in the presence of underlying myocardial disease [4].

According to the NATO Cardiology Working Group (2019) recommendations, any confirmed diagnosis of cardiomyopathy constitutes a basis for at least temporary disqualification from flying duties. A return to limited flight activity may be considered in asymptomatic individuals with a mild form of the disease, excluding cases of ARVC and RCM. This applies exclusively to non-critical flight crew members, in multi-crew aircraft, and excludes high-risk flight profiles [4].

Monitoring should include:

- ECG and TTE every 1–2 years,
- Cardiac MRI every 2–5 years,
- CPET every 2–3 years [2].

In the United States Air Force (USAF), the diagnosis of primary cardiomyopathy is generally considered disqualifying for further flying duties in pilots. Only in selected cases of DCM or HF is it possible to retain flying certification for other aircrew personnel [1].

CONCLUSIONS

Myocardial diseases, although relatively rare in the general population, pose a significant challenge in aviation medicine, particularly in the context of operational safety and precise medical certification. Rapid advances in imaging diagnostics, genetics, and risk assessment of sudden cardiac events now allow for a more individualized evaluation of each case.

An increasing body of evidence indicates that moderate, and in selected cases even intensive, physical activity may be safe for some patients diagnosed with cardiomyopathy—especially those with mild phenotypes of HCM, DCM, and NDLVC. This opens the door to a potential reinterpretation of certification approaches, particularly for experienced pilots who do not present high-risk features for life-threatening arrhythmias and SCD.

Despite this progress, cautious decision-making, individualized risk assessment, and strict clinical monitoring remain the foundation of aeromedical fitness determinations. Further studies are needed to more precisely define the boundaries of safe professional functioning for individuals with myocardial diseases in high-demand environments such as aviation.

AUTHORS' DECLARATION

Study Design: Michał A. Kurek, Magdalena Rola, Łukasz Dziuda. **Data Collection:** Michał A. Kurek, Magdalena Rola. **Manuscript Preparation:** Michał A. Kurek, Magdalena Rola. The authors declare that there is no conflict of interest.

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