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Aviation Medicine and Cardiovascular Assessment of Aircrew: A European Society of Cardiology–Aligned Review of Integrating International Civil Aviation Organization, European Union Aviation Safety Agency, Federal Aviation Administration, and Turkish Directorate General of Civil Aviation Aeromedical Standards

ABSTRACT

Aeromedical certification is based on a safety-first principle: a pilot or other aircrew member must not have a medical disorder that creates an unacceptable risk of sudden or subtle incapacitation during flight. Cardiovascular disease remains one of the most important determinants of flight fitness, as it may impair consciousness, judgment, rhythm stability, exercise capacity, and hemodynamic reserve. Modern aeromedical decision-making therefore requires the integration of aviation law, operational risk, contemporary cardiology guidelines, advanced imaging, biomarkers, and long-term surveillance. The International Civil Aviation Organization (ICAO) Annex 1 provides the global licensing framework; the European Union Aviation Safety Agency (EASA) Part-MED, together with its Acceptable Means of Compliance and Guidance Material, defines detailed operational standards in Europe; and the Federal Aviation Administration (FAA) employs a protocol- and special issuance–based system for many cardiovascular and metabolic disorders. This review summarizes the aeromedical assessment of hypertension, diabetes mellitus, chronic and acute coronary syndromes, heart failure, cardiomyopathies, arrhythmias and conduction disorders, pacemakers and implantable cardiac devices, valvular heart disease, aortic disease, congenital heart disease, venous thromboembolism, cardiovascular pharmacotherapy, and major respiratory conditions relevant to flight certification. The manuscript is aligned with current European Society of Cardiology cardiovascular guidance and with the operational aeromedical principles applied by ICAO, EASA, FAA, and the Turkish Directorate General of Civil Aviation. In general, preserved ventricular function, absence of significant symptoms, low thromboembolic and arrhythmic risk, stable treatment, and adequate exercise capacity support certification or restricted certification. In contrast, uncontrolled hypertension, unstable diabetes, significant residual myocardial ischemia, reduced ejection fraction, malignant ventricular arrhythmias, implantable defibrillator therapy, severe valvular disease, significant aortic pathology, major congenital hemodynamic lesions, or poorly controlled sleep apnea usually preclude certification. Final decisions remain individualized and depend on license class, operational role, treatment burden, surveillance data, and the judgment of the aeromedical authority.

Keywords: Aerospace cardiology, arrhythmia, aviation medicine, chronic coronary syndromes, diabetes mellitus, fitness to fly, heart failure, hypertension

INTRODUCTION

Aviation medicine differs fundamentally from routine clinical practice because the threshold for acceptable risk is substantially lower. In everyday clinical settings, patients may continue their professional and social activities despite moderate symptoms or partially controlled risk factors. In contrast, within the aviation environment, even a transient episode of chest pain, syncope, severe hypoglycemia, embolic stroke, arrhythmic instability, or acute dyspnea may pose a direct threat to flight safety and operational integrity.[1,2] For this reason, the International Civil

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Aviation Organization (ICAO) established medical provisions within Annex 1, forming the global regulatory framework for aeromedical certification, while national and regional authorities have developed structured assessment systems based on operational safety, recurrence risk, and the probability of sudden or subtle incapacitation.[1-3] From a cardiovascular perspective, aeromedical evaluation extends beyond conventional diagnostic assessment. It is inherently prognostic and operational. In addition to hypobaric hypoxia and operational stress, aviation-related environmental exposures such as aircraft noise may contribute to cardiovascular stress through autonomic activation, oxidative stress, inflammation, endothelial dysfunction, and sleep disturbance.[4] The central question is not solely whether a pilot has conditions such as coronary artery disease (CAD), atrial fibrillation (AF), diabetes mellitus, or an implanted cardiac device, but whether these conditions—or their treatments—may lead to sudden or insidious incapacitation, impair cognitive or physical performance, or generate an unacceptable level of residual risk relative to the privileges of the intended licence.[2,3,5] This review summarizes the fundamental principles for evaluating cardiovascular fitness in pilots in accordance with contemporary aviation medicine standards. Both pilot applicants and licensed aircrew are required to undergo medical fitness assessments conducted by authorized aeromedical examiners and competent regulatory authorities. Table 1 presents the standardized color-coded classification system for flight fitness, while Table 2 summarizes major international aviation authorities, aeromedical centers, and certification classes.

REGULATORY AND AEROMEDICAL FRAMEWORK

The international legal foundation of aeromedical licensing is ICAO Annex 1—Personnel Licensing, which sets the minimum standards for medical fitness of license applicants and holders.[1] The broader interpretive and practical framework is supported by the ICAO Manual of Civil Aviation Medicine (Doc 8984), which is explicitly intended to assist medical examiners and licensing authorities in decisions related to fitness for licensing.[6]

In Europe, detailed implementation is provided by European Union Aviation Safety Agency (EASA) Part-MED and its Acceptable Means of Compliance and Guidance Material (AMC/GM).[2] These documents define how cardiovascular, metabolic, respiratory, neurological, and other conditions should be approached for Class 1, Class 2, Light Aircraft Pilot Licence (LAPL), and related aeromedical certificates.[2,5] In Türkiye, Directorate General of Civil Aviation (DGCA) practice is broadly aligned with this EASA-based aeromedical framework.[7] The Federal Aviation Administration (FAA) uses a different but conceptually similar system in which some disorders are directly issuable, some require deferment, and others may be handled under Special Issuance or AME-Assisted Special Issuance pathways.[8]

Aeromedical Risk Assessment and the "1% Rule"

Aeromedical risk assessment frequently incorporates the "1% rule," according to which license privileges may be restricted or suspended when the estimated annual risk of sudden pilot incapacitation exceeds approximately 1%, particularly in multi-crew commercial aviation operations. This principle is derived primarily from operational aviation safety calculations rather than from purely clinical considerations and provides an important conceptual framework for aeromedical decision-making. It emphasizes that certification depends not only on the presence or severity of a medical condition, but also on the probability that the condition may cause sudden or subtle incapacitation during flight.[6]

Three practical consequences arise from this framework. First, "fit" is not binary: a pilot may be fit, fit with limitation, temporarily unfit, or unfit.[3,8] Second, license class matters: what may be acceptable for a private pilot or Class 2 certificate may still be unacceptable for a commercial, multi-crew, or Class 1 operational role.[2] Third, follow-up is dynamic:

Table 1. Aerospace Cardiology—Flight Fitness Color Codes

Color	Explanation
Green	Fit—Eligible to fly, fully fit.
Yellow	Conditionally Fit—May fly under certain conditions.
Orange	Restricted Flight Privileges – Requires close monitoring, may not fly if adverse health issues arise.
Red	Unfit—Not eligible for flying duties.

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Table 2. Aviation Medicine Authorities, Centers, and Certification Levels

Unit	Role/Explanation
ICAO	Global standard-setting body for civil aviation safety and medical regulations.
EASA	Responsible for civil aviation safety and medical certification in the EU.
FAA	Responsible for aviation safety and aeromedical certification in the USA.
JAA	Former European aviation authority; responsibilities transferred to EASA in 2009.
CAA	National aviation authority; in the UK, responsible for aviation safety and medical certification.
SHGM	Turkish Directorate General of Civil Aviation, national authority aligned with ICAO and EASA standards.
AME	Authorized by the aviation authority to perform medical examinations for flight personnel.
AeMC	Specialized center for advanced aeromedical examinations, required for some Class 1, 2, 3 and LAPL certificates.
AMS	Division within the aviation authority that reviews AME/AeMC reports.
AMAS	Provides online and telephone-based aeromedical consultation and FAA medical certification assistance to pilots and aviation professionals.
Medical Assessor	Physician within AMS who reviews reports and makes the final decision (Fit/Unfit/Restricted).
Class 1 Certificate	Commercial Pilots (ATPL and CPL)
Class 2 Certificate	Private Pilots (PPL)
LAPL Medical Certificate	Light Aircraft Pilot Licence (LAPL)
Class 3 Certificate	Air Traffic Controllers (ATCO)

AME, Aviation Medical Examiner, AeMC, Aeromedical Center, AMAS, Aviation Medicine Advisory Service, AMS, Aeromedical Section, ATCO, Air Traffic Controller, ATPL, Airline Transport Licence, CPL, Commercial Pilot Licence, CAA, Civil Aviation Authority, DGCA, Directorate General of Civil Aviation (Türkiye), EASA, European Union Aviation Safety Agency, FAA, Federal Aviation Administration, ICAO, International Civil Aviation Organization, JAA, Joint Aviation Authorities, LAPL, Light Aircraft Pilot Licence, PPL, Private Pilot Licence.

an aeromedical decision is never final in the same way as a routine clinic note; it must be revalidated against time, treatment changes, recurrent symptoms, and new tests.[5,8]

AEROMEDICAL CERTIFICATION CLASSES AND LIMITATION CODES

For the purposes of practical flight medicine, the most important certification classes are Class 1 for commercial pilots, Class 2 for private pilots, Class 3 for air traffic controllers, and LAPL for light aircraft pilot licensing.[2,5] The EASA and associated authorities also use limitation codes to mitigate risk rather than simply deny certification.[2] EASA Medical Certificate Limitation Codes with abbreviations and explanations are summarized in Table 3.

Relevant examples include OML (operational multi-crew limitation), OSL (operational safety pilot limitation), ORL, SSL, TML, and vision-related limitations such as VDL/VCL.[2,5] Operational limitations are especially important in cardiovascular disease. An applicant with a history of AF, coronary intervention, valve surgery, pacemaker implantation, or stable medication-controlled metabolic disease may not be unrestrictedly fit, but may still be certifiable under OML or another safety-reducing limitation if the aeromedical authority is satisfied that residual risk is sufficiently controlled.[2,5] EASA explicitly uses this logic in multiple cardiovascular sections.[2,5]

GENERAL CARDIOVASCULAR EVALUATION IN AIRCREW

Any aircrew member with known or suspected cardiovascular disease requires a structured assessment built around 5 pillars: clinical symptoms, hemodynamic impact, arrhythmic risk, structural heart disease, and treatment effects. The EASA's cardiovascular guidance requires that when a formal cardiovascular assessment is indicated, exercise electrocardiogram (ECG) should be symptom-limited and completed to at least Bruce Stage IV or equivalent. This threshold is operationally important because it helps to identify both ischemic burden and functional reserve.[2]

In practice, the baseline work-up usually includes history, physical examination, resting ECG, echocardiography, ambulatory rhythm monitoring when indicated, laboratory testing, and disease-specific advanced imaging such as stress imaging, coronary computed tomography angiography (CTA), invasive coronary angiography, or vascular imaging. In selected disorders, biomarkers such as brain natriuretic peptide / N-terminal pro-brain natriuretic peptide (BNP/NT-proBNP), troponin, hemoglobin A1C (HbA1c), renal function, and lipid profile are central to risk interpretation. Aeromedical evaluation is therefore a multidisciplinary process, not a single examination.[9]

HYPERTENSION AND FITNESS TO FLY

Hypertension is one of the most common findings in aeromedical practice. EASA states clearly that the diagnosis of hypertension should trigger cardiovascular evaluation including potential vascular risk factors.[2] This principle mirrors modern European Society of Cardiology (ESC) hypertension guidance, which treats hypertension not as an isolated number but as a disease integrated with total cardiovascular risk, organ damage, obesity, renal function, diabetes, and overall vascular burden. The current recommendations are based on ESC hypertension guidelines published in 2024.[10]

From an aeromedical standpoint, the key questions are: Is blood pressure controlled? Is there left ventricular

Table 3. EASA Medical Certificate Limitation Codes

Code	Expansion	Meaning	Example Situations
SIC	Specific regular medical examination(s)	AME or AeMC cannot conduct the examination without consulting the licensing authority's medical assessor. Additional tests/follow-up required.	Kidney stones story, prediabetes, suspected heart disease, etc.
OML	Operational Multi-crew Limitation	Pilot cannot fly alone, only allowed in multi-crew operations.	Arrhythmia, coronary artery disease, Kidney stones , diabetes controlled epilepsy risk
ORL	Valid only with a safety pilot if passengers are carried	Valid only with a safety pilot if passengers are carried and in aircraft with dual controls	This limitation applies to holders of a class 2 or LAPL medical certificate with a medical condition that may lead to an increased level of risk to flight safety when exercising the privileges of the licence. The safety pilot, if carried, should be made aware of the type(s) of possible incapacity that the pilot whose medical certificate has been issued with this limitation may suffer and should be prepared to take over the aircraft controls during flight.
OSL	Operational Safety Pilot Limitation	Pilot cannot fly without a second pilot (safety pilot).	Vision impairment, temporary neurological conditions
SSL	Special restriction(s) as specified	This limitation may be considered when an individually specified limitation, not defined in this AMC, is appropriate to mitigate an increased level of risk to flight safety..	The description of the SSL should be entered on the medical certificate or in a separate document to be carried with the medical certificate. medical stabilization period
VDL	Valid only with corrective lenses	Pilot must wear glasses or contact lenses during flight.	Myopia, hypermetropia, astigmatism
VCL	Valid by day only	holders of a medical certificate with varying degrees of colour deficiency, to exercise the privileges of their licence by daytime only.	Mild vision defects
TML	Time Limitation	Certificate validity is shorter than usual, frequent checks required.	Newly diagnosed illness, medication initiation period
CML	Colour perception Limitation	Pilots with color blindness may face operational restrictions.	Color blindness (failure in Ishihara test)

hypertrophy, renal disease, cerebrovascular disease, or coronary disease? Is the treatment compatible with safe flying? And is the applicant in a category where sudden stroke, acute hypertensive destabilization, or treatment-related hypotension could compromise safety? Uncontrolled hypertension generally leads to temporary unfitness until evaluation and treatment are completed. Borderline hypertension without other major risk factors may allow short-interval review, but persistent elevation requires a formal decision pathway.[2]

Medication compatibility matters. The EASA's AMC/GM identifies acceptable classes such as non-loop diuretics, angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers, calcium-channel blockers, and selected hydrophilic beta-blockers. By contrast, medications with substantial CNS effects or orthostatic burden are less desirable in flight personnel.[2] The FAA materials also treat hypertension in a structured certification framework, with emphasis on acceptable therapy, tolerability, and absence of aeromedically significant side effects.[8]

Aircrew with controlled blood pressure, no symptoms, no hypertension-mediated organ damage, and well-tolerated acceptable therapy may be considered fit or fit with an operational limitation, depending on license class. By contrast, uncontrolled hypertension, major comorbidity, medication intolerance, or hypertension-mediated organ

Table 4. Flight Fitness in Hypertensive Individuals

Hypertension Status	Flight Fitness	Possible Limitations
Uncontrolled hypertension	Unfit	—
Untreated but borderline hypertension (and no additional risk factor)	Conditionally fit	Follow-up required
Stable and well-controlled hypertension with appropriate medication (Class 1)	Fit	OML may apply
Stable and well-controlled hypertension with appropriate medication (Class 2)	Fit	OSL may apply
Renal disease or hypertension-related organ damage	Requires individual assessment	—

OML, operational multi-crew limitation; OSL, operational safety pilot limitation.

damage warrants temporary unfitness or unfitness until adequate clinical stability has been documented.[2] Serial lipid assessment and comprehensive cardiovascular risk-factor management remain important, particularly after the age of 40.[2,10] The regulations regarding hypertensive aircrew are presented in Table 4.

DIABETES MELLITUS AND FITNESS TO FLY

Diabetes is highly relevant to aeromedical certification because it may impair safety in 2 distinct ways: acutely, through hypoglycemia and cognitive dysfunction; and chronically, through accelerated atherosclerosis, autonomic dysfunction, retinopathy, nephropathy, and cerebrovascular disease. European Union Aviation Safety Agency's rule text is explicit: applicants with diabetes mellitus requiring insulin shall be assessed as unfit, while applicants with diabetes not requiring insulin are unfit unless stable blood sugar control can be demonstrated.[2] The EASA further states that applicants not requiring medication may be assessed as fit and that antidiabetic medications not likely to cause hypoglycemia may be acceptable, often with an OML.[2] Applicants with body mass index (BMI) ≥35 may be assessed as fit only after satisfactory risk assessment including cardiovascular review and evaluation of possible sleep apnea.[2]

The FAA is more protocol-driven and, importantly, more nuanced in current practice. Its diabetes disposition tables and protocol pages show that medication-controlled non-insulin diabetes may be considered under special issuance pathways and that even some insulin-treated applicants may be considered under structured protocols, especially with defined monitoring requirements.[8] Insulin therapy should not be regarded as an absolute and universal bar to aeromedical certification. Under EASA provisions, applicants with insulin-treated diabetes are generally assessed as unfit, whereas the FAA may consider selected applicants through a special issuance pathway after documented metabolic stability and compliance with the required monitoring protocol.[2,8] Clinically, the aeromedical assessment of diabetes should include HbA1c, hypoglycemia history, treatment class, renal function, retinal status, neuropathy, coronary risk, obesity, and coexistence of hypertension or dyslipidemia. Modern ESC diabetes guidance emphasizes cardiovascular risk assessment and intensive preventive management in diabetic patients, reinforcing why diabetes in pilots should never be viewed as a purely metabolic issue.[11] It is a cardiovascular disease modifier and often a multiplier of aeromedical risk.

Accordingly, aircrew with diet-controlled diabetes or treatment with agents carrying a low risk of hypoglycemia, stable glycemic control, and no clinically relevant target-organ damage may be considered fit or conditionally fit following specialist assessment. Recurrent hypoglycemia, unstable glycemic control, advanced diabetic complications, or major cardiovascular comorbidity warrants deferment and may preclude higher-class certification. Fitness to fly in individuals with diabetes is assessed according to their clinical status, treatment regimen, and risk of hypoglycemia (Table 5).

ISCHEMIC HEART DISEASE, CHRONIC CORONARY SYNDROMES, AND ACUTE CORONARY SYNDROMES

Coronary artery disease is central to aeromedical cardiology because it can produce angina, myocardial infarction, ventricular dysfunction, malignant arrhythmia, and sudden death. The current ESC chronic coronary syndromes guideline is the 2024 version, and the current ACC/AHA acute coronary syndromes guideline is the 2025 version. Together, these define the contemporary cardiology framework for diagnosis, risk assessment, imaging, and treatment.[12,13]

In aviation medicine, the problem is not only the diagnosis of coronary disease, but the annual risk of incapacitation associated with that disease. The ICAO's risk-based philosophy has historically been expressed through the "1% rule" concept in operational aeromedicine: flight duties are not considered acceptable when the residual annual risk of acute incapacitation is too high for the role. Although exact thresholds and applications vary by authority, the principle remains foundational.[6,14]

Diagnostic evaluation should follow an ESC-style stepped framework: pre-test probability, resting assessment, anatomical or functional confirmation, and ischemic risk stratification. In pilots, the threshold for reassurance is higher than that in ordinary clinical practice. Exercise ECG, stress imaging, coronary CTA, and invasive angiography are used not only to diagnose but to document stability and operational safety. EASA specifically requires Bruce Stage IV or equivalent when exercise ECG forms part of the cardiovascular assessment.[2,12]

Table 5. Flight Fitness in Diabetic Patients

Diabetes Status (Class 1-2)	Flight Fitness	Possible Limitations
Insulin-treated diabetes	Generally unfit under EASA; selected applicants may be considered under an FAA special issuance pathway	Authority-specific assessment and intensive glucose-monitoring protocol required
Diabetes controlled with OAD	Conditionally fit	Regular follow-up required, low risk of hypoglycemia
Diabetes controlled with diet	Conditionally fit	Regular follow-up required
BMI > 35 kg/m^2	Conditionally fit	Cardiovascular risk assessment required
Additional risk (smoking, HT, obesity, etc.)	Further examination required	Regular monitoring of blood lipids and cholesterol

BMI, body mass index; HT, hypertension; OAD, oral antidiabetics.

As a practical aeromedical principle, preserved EF, complete revascularization when indicated, absence of residual ischemia, good exercise capacity, and stable clinical course are the minimum conditions for possible recertification. A pilot with residual angina, reduced EF, significant unrevascularized stenosis, abnormal functional testing, recurrent acute coronary syndrome (ACS), or complex multivessel disease should be considered unfit until a higher authority determines otherwise. The FAA materials also continue to treat coronary heart disease as a structured special issuance category rather than a routine issue condition.[2,8]

In percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), and post-myocardial infarction certification, return to flight should require an adequate waiting period, documented recovery, negative or acceptable stress imaging findings, satisfactory echocardiographic evaluation, and the absence of high-risk rhythm or hemodynamic abnormalities. Although timelines may vary slightly among regulatory authorities, none permits immediate unrestricted return to flight following coronary intervention.[2,8,12-14] Table 6 summarizes the aeromedical evaluation of ischemic heart disease across various clinical scenarios.

.HEART FAILURE AND FITNESS TO FLY

Heart failure is a major aeromedical concern because it reduces hemodynamic reserve and exercise performance while increasing the risks of arrhythmia, syncope, pulmonary congestion, and sudden deterioration. The current ESC basis is the 2021 heart failure guideline together with the 2023 focused update, which incorporated newer trial evidence ahead of the next full guideline cycle.[15,16]

Aeromedically, heart failure should be stratified by phenotype, EF, New York Heart Association (NYHA) class, natriuretic peptides, exercise capacity, pulmonary pressures, rhythm status, and device therapy. Only a narrow subgroup—typically those with preserved EF, asymptomatic or minimally symptomatic status, and durable stability—can be considered for possible certification. Patients with reduced EF, recent decompensation, pulmonary hypertension, recurrent hospitalization, or any meaningful risk of sudden deterioration are generally unfit.[2,8]

Guideline-directed medical therapy must be optimized, but treatment alone does not restore flight fitness. An applicant taking ARNI, beta-blocker, MRA, and SGLT2 inhibitor may be well treated from a cardiology perspective, yet still remain

Table 6. Ischemic Heart Diseases and Flight Fitness Based on Clinical Scenarios

Clinical Status	Flight Fitness (Class 1)	Flight Fitness (Class 2/3/LAPL)	Possible Limitations
All cases with EF <50%	Unfit for flight	Individual assessment/ OSL (rare cases)	EF <50% is a disqualifying criterion for flight fitness.
Complete revascularization, EF ≥50%	OML	ORL/SSL	Exercise test and myocardial perfusion scan (MPS) must be negative; anatomical suitability is required.
Non-revascularized, EF ≥50%	Unfit for flight	Individual assessment/ OSL	High-risk coronary anatomy—flight fitness may be granted only in rare individual cases.
Normal coronary angiography or CCS-CT <100, EF ≥50%	Fit for flight	Fit for flight	All cardiovascular risk factors must be optimally controlled; periodic follow-up is mandatory.
Post-STEMI PCI, ≥6 months, EF ≥50%	OML	ORL	Stable, completely revascularized cases with negative functional tests may be considered fit.
Elective PCI, ≥3 months, EF ≥50%	OML	ORL	Single-vessel lesion with FDA-approved stent and no symptoms—may be accepted as fit.
Post-CABG, ≥6 months, EF ≥50%	OML	ORL	Negative functional tests; MPS mandatory at the fifth year of follow-up.
Single-vessel disease, EF ≥50%, asymptomatic	OML	ORL	Stenosis <50%, LAD or left main <30%; CCS-CT) <400 is acceptable.
Two-vessel disease with <50% stenosis, EF ≥50%, asymptomatic	OML	ORL	Stenosis <50%, LAD or left main <30%; CCS-CT) <400 is acceptable.
More than 2 stenoses between 30% and 50%, or left main/proximal LAD >30% stenosis, or single-vessel stenosis >50%	Unfit for flight	Unfit for flight	A maximum of 2 vessels may have 30%-50% stenosis; if 3 vessels are involved, flight fitness must be denied.

CABG, coronary artery bypass grafting; CCS-CT, coronary calcium score computed tomography; EF, ejection fraction; FDA, Food and Drug Administration; LAD, left anterior descending; LAPL, Light Aircraft Pilot Licence; MPS, myocardial perfusion scintigraphy; OML, operational multi-crew limitation; ORL, operational pilot restriction limitation; OSL, operational safety pilot limitation; PCI, percutaneous coronary intervention; SIC, specific regular medical examination(s); SSL, specific safety pilot limitation.

unfit aeromedically if exercise capacity is inadequate, EF is reduced, or arrhythmic substrate persists. Likewise, implantable cardioverter-defibrillator (ICD) implantation is usually incompatible with active flying because it signals both serious underlying risk and the possibility of device shocks or pre-shock incapacitation. Selected CRT-P recipients may be considered on an exceptional basis if ventricular function, rhythm stability, and follow-up data are very favorable.[2,8,14-16] Flight fitness in heart failure is summarized in Table 7.

CARDIOMYOPATHIES

Cardiomyopathies are highly relevant in aviation medicine because they represent a heterogeneous group of diseases associated with variable but potentially significant risks of ventricular arrhythmias, heart failure progression, thromboembolic events, and sudden cardiac death.[2,7,17] The recommendations discussed in this review are based on the most up-to-date international cardiology and aviation medicine guidelines available at the time of manuscript preparation.

Cardiomyopathies require phenotype-specific aeromedical assessment because their hemodynamic, arrhythmic, and sudden-incapacitation risks differ substantially. Dilated cardiomyopathy raises concerns about reduced EF and ventricular tachyarrhythmia. Hypertrophic cardiomyopathy raises concerns about syncope, dynamic obstruction, AF, ventricular tachyarrhythmia, and sudden death risk.[7,17,18] Restrictive cardiomyopathies raise concerns about filling instability, pulmonary hypertension, and embolic/arrhythmic burden.[17] Arrhythmogenic right ventricular cardiomyopathy is particularly concerning because of its strong association with malignant ventricular arrhythmias and exercise-related sudden death.[17,19] Beyond structural and functional parameters, the 2023 ESC Guidelines for the management of cardiomyopathies identify a group of high-risk arrhythmic genes, including *PLN*, *FLNC*, *RBM20*, *DSP*, and *LMNA*, which confer a risk of malignant ventricular arrhythmias that may be disproportionate to the degree of ventricular dysfunction across both the dilated and arrhythmogenic cardiomyopathy spectrum. Gene-specific risk calculators should be considered where available. Applicants carrying a high-risk genotype require individualized arrhythmic risk assessment independent of ejection fraction, and preserved systolic function alone should not be interpreted as reassuring in this subgroup. Takotsubo syndrome and transient secondary cardiomyopathies may be reconsidered only after complete recovery and prolonged stability.[2,17]

As an aeromedical rule, the combination of structural cardiomyopathy plus reduced EF, prior sustained ventricular arrhythmia, unexplained syncope, ICD implantation, or high-risk imaging/genetic profile should be considered incompatible with certification.[2,7,17] A very small subset of asymptomatic, preserved EF, stable patients without arrhythmic burden may qualify for individualized restricted certification, but this is the exception rather than the rule.[2,7,17] Various cardiomyopathy conditions and their corresponding flight fitness requirements are summarized in Table 8.

ARRHYTHMIAS, CONDUCTION DISEASE, AND PACEMAKERS

European Union Aviation Safety Agency specifically identifies AF/flutter, major supraventricular rhythm disturbance, complete left bundle branch block, and several conduction disorders as conditions requiring referral and specialist cardiovascular evaluation.[2,7] Applicants with supraventricular rhythm disorders may be assessed as fit if cardiological evaluation is satisfactory and stroke risk is sufficiently low; where anticoagulation is required, ORL or OSL may be considered after a stable anticoagulation period.[2,7] European Union Aviation Safety Agency also states that asymptomatic pre-excitation may be acceptable if electrophysiologic criteria are favorable and that pacemaker recipients may be considered no sooner than 3 months after implantation if they are not pacemaker-dependent, have a bipolar lead system, and undergo regular follow-up.[2,7,20]

The current ESC arrhythmia framework is derived primarily from the 2024 AF guideline, the 2022 ventricular arrhythmia and sudden cardiac death guideline, the 2021 pacing guideline, and the 2019 supraventricular tachycardia guideline, which together constitute the most comprehensive contemporary ESC-aligned basis for aeromedical rhythm assessment.[20-23] This combination is the best contemporary ESC-aligned base for an aviation review. In practical terms, benign sinus bradycardia or sinus tachycardia in the absence of structural heart disease may be compatible with medical certification following appropriate cardiovascular evaluation.[2,22,23] Atrial fibrillation/flutter

Table 7. Heart Failure Types and Fitness for Flight

Clinical Status	Flight Fitness	Possible Limitations
EF < 50% (all classes)	Unfit	Disqualified
EF ≥ 50% (HFpEF), NYHA I, ≥6 months stable, exercise ≥ 7 METs	Fit	None
EF ≥ 50%, NYHA II	Conditionally fit	OML and follow-up required (SIC or TML for monitoring)
EF ≥ 50%, PASP > 50 mm Hg	Unfit	Disqualified
CRT-P present, EF ≥ 50%, stable rhythm ≥ 6 months	Conditionally fit	Individual assessment
Presence of ICD or VAD	Unfit	Disqualified

CRT-P, cardiac resynchronization therapy with pacemaker; EF, ejection fraction; HFpEF, heart failure with preserved ejection fraction; ICD, implantable cardioverter-defibrillator; OML, operational multi-crew limitation; PASP, pulmonary artery systolic pressure, estimated by Doppler echocardiography; SIC, specific regular medical examination; TML, time limitation; VAD, ventricular assist device; NYHA, New York Heart Association.

Table 8. Cardiomyopathies and Aeromedical Fitness

Clinical Condition	Flight Fitness	Possible Limitations
EF <50%	Unfit	Disqualified
EF ≥50%, NYHA I, ≥6 months stable, exercise ≥ 7 METs	Fit	None
EF ≥50%, NYHA II	Conditionally fit	OML and follow-up
HCMP, EF ≥50%, septum <25 mm, asymptomatic, no arrhythmia	Conditionally fit	OML/ORL/SSL—annual follow-up required
HCMP + VT / septum ≥25 mm / unexplained syncope	Unfit	Disqualified
Diagnosed ARVC	Unfit	Disqualified
Takotsubo/transient CMP (EF ≥50%, ≥6 months stable)	Restricted flight privileges	Individual assessment
Presence of ICD or VAD	Unfit	Disqualified
A group of high-risk arrhythmic genes, including *PLN*, *FLNC*, *RBM20*, *DSP*, and *LMNA*	Unfit	Disqualified

ARVC, arrhythmogenic right ventricular cardiomyopathy; CRT-P, cardiac resynchronization therapy pacemaker; EF, ejection fraction; HCMP, hypertrophic cardiomyopathy; HFrEF, heart failure with reduced ejection fraction; ICD, implantable cardioverter-defibrillator; OML, operational multi-crew limitation; ORL, operational restriction limitation; SSL, special safety pilot limitation; VAD, ventricular assist device; VT, ventricular tachycardia.

may be considered compatible with certification after satisfactory cardiological evaluation if ventricular rate and rhythm control are adequate, thromboembolic risk is low or appropriately mitigated, and the applicant is clinically stable on therapy.[2,8,21] Under EASA Part-MED, revalidation may be possible when stroke risk is sufficiently controlled and anticoagulation is stable; for vitamin K antagonist therapy, stability generally requires at least 5 international normalized ratio (INR) measurements within the previous 6 months with at least 4 values within the therapeutic range, whereas direct oral anticoagulants (DOACs) may be acceptable after a stabilization period of approximately 3 months.[2] Following catheter ablation, temporary unfitness is recommended, with possible return to flying duties after successful evaluation, often with an operational multi-pilot limitation (OML) for at least 1 year unless electrophysiological testing demonstrates satisfactory early results.[2] Federal Aviation Administration guidance similarly allows AME-Assisted Special Issuance for AF when there is no evidence of thromboembolic complications, ventricular rate control is satisfactory on monitoring, symptoms are well controlled, and anticoagulation management is acceptable; cases with poor rate control, interval embolic events, unstable anticoagulation, significant bleeding, or associated structural cardiac disease generally require FAA deferral and specialist review.[8] Following successful catheter ablation of atrioventricular nodal re-entrant tachycardia (AVNRT) or atrioventricular re-entrant tachycardia (AVRT), aeromedical recertification should balance the small but clinically relevant risk of recurrence against the occupational consequences of disproportionate restriction. Current regulatory approaches differ. European Union Aviation Safety Agency generally requires an operational multi-pilot limitation (OML) for at least 1 year unless an electrophysiological study (EPS), performed no earlier than 2 months after ablation, demonstrates satisfactory results.[2] The FAA permits reconsideration after a 3-month observation period, provided that a 24-hour Holter recording shows no evidence of recurrent arrhythmia.[8] Similarly, the Turkish DGCA, in its Algorithms and Guidance Document within the Scope of SHT-MED, requires an initial 2-month period of unfitness following catheter ablation for Wolff–Parkinson–White (WPW) syndrome or AVNRT, followed by a cardiological evaluation including exercise electrocardiography, 24-hour ambulatory ECG monitoring, and transthoracic echocardiography. The DGCA guidance recommends a follow-up EPS with pharmacological provocation after successful ablation of inducible arrhythmias, including AVNRT and AVRT, and permits unrestricted certification when the post-ablation EPS findings are satisfactory. If EPS is not performed, Class 1 recertification is generally subject to an OML for 1 year, together with appropriate cardiological follow-up. When follow-up EPS is not considered necessary, fitness may be granted if Holter monitoring performed 3 months after successful ablation demonstrates no recurrent arrhythmia.[7] No comparative evidence has established that any of these strategies provides superior flight-safety outcomes. Although 24-hour Holter monitoring has limited sensitivity for detecting infrequent paroxysmal supraventricular tachycardia, routine repeat invasive EPS in every asymptomatic aircrew member is not supported by contemporary clinical guidelines or practice. Furthermore, residual dual AV-nodal physiology or isolated AV-nodal echo beats should not, in isolation, be regarded as recurrence of clinical AVNRT.[23] Accordingly, recertification should comply with the requirements of the applicable aviation authority and should confirm an appropriate procedural endpoint at the index ablation, absence of pre-excitation and clinically relevant symptoms, discontinuation of antiarrhythmic medication where appropriate, and absence of recurrence during the prescribed observation period. Extended ambulatory ECG monitoring may provide greater reassurance than a conventional 24-hour Holter recording, particularly when symptoms are infrequent. Repeat EPS with pharmacological provocation is most appropriately reserved for cases in which it is required by the applicable regulation or guidance, or in which the procedural endpoint, symptoms, arrhythmic mechanism, or risk of recurrence remains uncertain. Inducibility of sustained clinical AVNRT or

AVRT should prompt further electrophysiological evaluation; however, isolated and non-specific electrophysiological findings should not automatically result in a determination of aeromedical unfitness.[2,7,8,23]

Ventricular tachycardia, symptomatic broad-complex tachycardia, dangerous pre-excitation, high-grade AV block without appropriate treatment, or recurrent syncope are usually disqualifying.[2,20,22] Pacemaker implantation may permit restricted return to flight under authority supervision; ICD implantation does not.[2,7,20] Federal Aviation Administration materials likewise treat AF, pacemakers, bundle branch block, and other arrhythmias through structured disposition tables and FAA decision pathways rather than unrestricted routine issuance.[7,8]

The aeromedical assessment of aircrew with suspected or documented cardiac arrhythmias requires a structured and comprehensive cardiological evaluation, as rhythm disturbances may lead to syncope, impaired consciousness, hemodynamic instability, or sudden incapacitation during flight. Therefore, the initial evaluation must be sufficiently detailed to identify the type of arrhythmia, its underlying mechanism, the presence of structural heart disease, and the potential risk of recurrence.[2,8,22] During the initial assessment, a comprehensive cardiologist's report is mandatory. The diagnostic work-up should include, at minimum, a 12-lead ECG, symptom-limited exercise stress testing, 24-hour Holter rhythm monitoring, and transthoracic echocardiography to evaluate structural cardiac abnormalities and ventricular function. These examinations are essential for determining the hemodynamic significance of the arrhythmia and for identifying any associated structural heart disease. When clinically indicated, EPS or other advanced diagnostic investigations—such as extended rhythm monitoring, stress imaging, or cardiac magnetic resonance imaging—may be required to clarify the arrhythmic substrate and guide aeromedical decision-making.[2,8,22] Aircrew with documented arrhythmias or those who have undergone implantation of a permanent pacemaker require structured periodic follow-up, as both the arrhythmia itself and device-related factors may influence long-term flight safety. During the first year after diagnosis or device implantation, cardiological evaluations should generally be performed at 3- to 6-month intervals to ensure rhythm stability, adequate device function, and absence of hemodynamic compromise. After this initial period of stabilization, annual follow-up examinations are typically considered sufficient in individuals who remain clinically stable.[2,8,20] Follow-up assessment should include clinical review, electrocardiographic monitoring, device interrogation in pacemaker recipients, and additional investigations when clinically indicated.[2,8,20] If clinical deterioration, recurrence of significant arrhythmia, worsening ventricular function, or device malfunction is identified, the individual's fitness for flight must be reassessed immediately, and temporary suspension of flight duties may be required until the condition is adequately evaluated and stabilized.[2,8,20] Given the potentially serious consequences of arrhythmic events during flight operations, fitness-to-fly decisions in various arrhythmic conditions must be made with particular caution and should be individualized according to the specific arrhythmia type, underlying cardiac condition, treatment status, and long-term risk profile.[2,8,20,22] A structured summary of aeromedical decision pathways for different arrhythmic conditions is presented in Table 9.

Table 9. Arrhythmias and Flight Fitness

Clinical Condition	Flight Fitness	Possible Limitations
Sinus bradycardia/tachycardia	Fit (if asymptomatic)	None
AF (single episode)	Conditionally fit	OML restriction following AMS assessment
AF (with anticoagulant use)	Conditionally fit	OML, following a 3- to 6-month stabilization period
Wolff–Parkinson–White (WPW) Syndrome	Conditionally fit	if no tachycardia induced during EPS, OML may be applied after evaluation
Catheter ablation	Conditionally fit	1-year OML after a 2- to 3-month post-ablation waiting period
First-degree AV block	Fit	None
Mobitz type I AV block	Fit	Follow-up recommended
Mobitz type II/complete AV block	Unfit (if untreated)	OML (if pacemaker implanted)
Monomorphic ventricular extrasystole	Fit (if asymptomatic)	None
Wide/narrow QRS tachycardias	Unfit	Disqualified
Ventricular pre-excitation	Unfit	Disqualified unless proven safe by EPS
Incomplete right bundle branch block	Fit (if no structural heart disease)	None
Complete right bundle branch block	Conditionally fit	Following AMS assessment, OML may be applied
Complete left bundle branch block	Conditionally fit	Coronary artery evaluation required; OML applied for 3 years, which may be lifted if the condition remains stable
Pacemaker	Conditionally fit	First 3 months flight restriction, followed by re-evaluation; OML may be applied for Class 1, while generally no restriction is required for Class 2.

AF, atrial fibrillation; AMS, Aeromedical Section; EPS, electrophysiological study; OML, operational multi-crew limitation.

VALVULAR HEART DISEASE

Valve disease remains operationally important because stenosis, regurgitation, chamber remodeling, pulmonary hypertension, embolic risk, anticoagulation, and postoperative valve status may all affect flight safety.[2,8,24] The current ESC/EACTS valvular guideline is the 2025 update, replacing the 2021 version as the latest ESC/EACTS reference.[24] The EASA also provides explicit valvular aeromedical rules.[2] EASA states that previously unrecognized cardiac murmurs require cardiological evaluation and that minor valvular abnormalities may be assessed as fit, whereas significant abnormalities of any valve should be assessed as unfit.[2] For aortic valve disease, bicuspid aortic valve may be acceptable if no other cardiac or aortic abnormality is present.[2] EASA further states that applicants with left ventricular volume overload or systolic impairment due to valve disease should be assessed as unfit.[2]

After valve surgery, Class 1 applicants may be reconsidered only after at least 6 months, with satisfactory exercise ECG and 2D Doppler echocardiography; when anticoagulation is needed, stable INR documentation is required and OML may be considered.[2] Accordingly, it should be stated that mild asymptomatic valve disease with preserved ventricular response may be compatible with certification, but moderate-to-severe disease, symptomatic valve disease, progressive chamber enlargement, pulmonary hypertension, or unstable postoperative status usually preclude unrestricted licensing.[2,24] Mechanical valves and anticoagulation do not automatically prohibit all licensing, but they substantially raise the threshold for acceptable Class 1 certification. All individuals with valvular heart disease must undergo comprehensive cardiologic assessment.[2,8,24]

Previously undiagnosed cardiac murmurs or murmurs whose acoustic characteristics have changed during follow-up require prompt cardiological evaluation, as they may represent previously unrecognized structural heart disease or progressive valvular pathology. From an aeromedical perspective, the presence of a murmur is not itself disqualifying; however, the underlying cause must be clearly identified and its hemodynamic significance carefully assessed before certification can be considered.[2,24-26] In Class 1 and Class 3 license holders, evaluation of an undiagnosed murmur requires mandatory review by the AMS following specialist cardiology assessment. For Class 2 and LAPL applicants, initial evaluation may be performed by the AME, but consultation with the AMS is recommended whenever uncertainty exists regarding the hemodynamic significance of the murmur or its potential operational implications.[2,25] Diagnostic evaluation must include transthoracic echocardiography with 2-dimensional imaging and Doppler assessment or an equivalent advanced imaging modality capable of accurately defining valvular anatomy, transvalvular gradients, ventricular dimensions, and hemodynamic consequences. Minor valvular abnormalities without functional impairment may be compatible with certification. In contrast, significant valvular dysfunction, progressive chamber enlargement, or evidence of hemodynamic compromise should lead to a determination of unfitness until full evaluation and stabilization are achieved.[2,24-26] The flight fitness criteria for specific valvular diseases are summarized separately below under the headings of aortic valve disease, mitral valve disease, valve surgery, and fitness for flying.

Aortic Valve Diseases in Aeromedical Assessment

Bicuspid Aortic Valve

Bicuspid aortic valve (BAV) is the most common congenital cardiac anomaly and is frequently detected incidentally during echocardiographic evaluation performed after auscultation of a cardiac murmur.[24,27] Although many individuals with BAV remain asymptomatic for long periods, the condition is clinically important because it may be associated with progressive aortic stenosis, aortic regurgitation, and dilatation of the aortic root or ascending aorta.[24,27] In the aeromedical context, applicants with BAV may be considered fit for certification when no associated structural abnormalities are present, ventricular function is normal, and there is no clinically significant aortic dilatation.[2] Regular echocardiographic surveillance is required because progressive aortic enlargement or valve dysfunction may occur over time.[2,24,28] The frequency of echocardiographic follow-up should be determined by the AMS according to valve morphology, aortic dimensions, and clinical stability.[2,24] Certification may become impossible when significant aortic root or ascending aortic dilatation develops, as this condition carries an increased risk of progressive enlargement, dissection, or rupture—events that would represent unacceptable aeromedical risk.[2,28]

Aortic Stenosis

Aortic stenosis is particularly relevant to aviation medicine because progressive obstruction of left ventricular outflow may lead to reduced exercise tolerance, syncope, heart failure, arrhythmias, and sudden cardiac death.[2,24] Aeromedical assessment must therefore consider the severity of the stenosis, ventricular function, symptom status, and hemodynamic response to exercise.[2,24] Applicants with mild aortic stenosis, defined by a mean transvalvular gradient ≤20 mmHg with preserved left ventricular function, may generally be considered eligible for unrestricted certification, provided that they remain asymptomatic and undergo periodic cardiological follow-up.[2,24]

Moderate aortic stenosis, typically defined by a mean gradient between 20 and 40 mm Hg with an aortic valve area >1 cm^2 or indexed valve area >0.6 cm^2/m^2, may allow certification with operational limitations if the individual remains asymptomatic and ventricular function is preserved. In such cases, exercise testing and serial echocardiographic surveillance are essential components of aeromedical follow-up.[2,24]

In selected individuals with mean gradients between 40 and 50 mm Hg, certification may occasionally be considered at the discretion of the AMS, provided that a symptom-limited exercise test demonstrates normal functional capacity without hemodynamic instability and that no abnormal

increase in biomarkers such as BNP or NT-proBNP is detected. However, gradients exceeding this range generally indicate advanced disease and are considered incompatible with flight duties because of the risk of sudden hemodynamic deterioration.[2,24]

Regular cardiological follow-up and periodic echocardiography are required in all individuals with aortic stenosis.[2,24] A history of systemic embolism or marked dilation of the thoracic aorta is considered disqualifying for all license classes, as these conditions substantially increase the risk of in-flight incapacitation.[2]

Aortic Regurgitation

Aortic regurgitation may be compatible with aviation duties when the regurgitation is mild and ventricular size and function remain normal. Trivial aortic regurgitation, particularly when detected incidentally during echocardiography, may allow certification provided that regular cardiological and echocardiographic follow-up is maintained.[2,24] In some cases, a slight increase in left ventricular end-diastolic diameter (LVEDD) may still be considered acceptable for Class 1 licence holders, particularly when ventricular systolic function remains preserved and the individual remains asymptomatic. In such situations, certification is generally granted with OML (operational multi-crew limitation) in order to minimize operational risk.[2] However, when LVEDD exceeds 6.0 cm, the degree of ventricular dilatation reflects excessive volume loading and indicates significant hemodynamic impact of the regurgitant lesion. In this situation, the applicant should be considered unfit for certification, as progressive ventricular dilatation and deterioration of ventricular function may occur and could compromise flight safety.[2,24] Flight fitness criteria for aortic valve diseases are presented in Table 10.

Mitral Valve Diseases in Aeromedical Assessment

Rheumatic Mitral Disease

Aircrew presenting with mitral valve disease must be evaluated according to specified aeromedical criteria.[2] In the context of rheumatic mitral valve disease, the presence of rheumatic mitral stenosis and/or regurgitation constitutes an aeromedically significant condition and applicants are generally considered unfit for certification.[2,29] However, individuals exhibiting minor mitral leaflet tethering may be considered for Class 1 certification with an operational multi-crew limitation (OML), provided they remain in sinus rhythm and show no evidence of left atrial enlargement.[25] Furthermore, mild mitral stenosis, characterized by a valve area greater than 2 cm^2, may permit Class 2 certification with

Table 10. Aortic Valve Diseases and Flight

Clinical Condition	Flight Fitness	Possible Limitations
Bicuspid aortic valve	Fit (If there is no other cardiac or aortic abnormality. Follow-up with echocardiography as determined by AMS.)	None
Aortic stenosis		
Mean pressure gradient up to 20 mm Hg	May be considered fit	Unrestricted certification if asymptomatic with preserved LV function.
Mean pressure gradient 20-40 mmHg and valve area >1 cm^2 or AVAI >0.6 cm^2/m^2	Conditionally fit	Requires regular exercise testing and echocardiographic follow-up. OML, SSL (Class 1), ORL, OSL, OPL, (Class 2, LAPL), SSL (Class 3)
Mean pressure gradient 40-50 mmHg	Conditionally fit	Restricted certification may be considered by AMS if exercise test and biomarkers are normal.
Mean pressure gradient >50 mmHg	Unfit	Disqualified
Valve area ≤1 cm^2	Unfit	Disqualified
History of systemic embolism or significant thoracic aortic dilatation	Unfit	Disqualified
Aortic regurgitation		
Mild aortic regurgitation with normal ascending aorta	Fit	For mild or trivial AR with normal LV size and function, with regular follow-up.
Mild increase in LVEDD	Conditionally fit	If LV size/function are normal, with follow-up. Class 1 OML.
More marked increase in LVEDD without an increase in LVESD (>4.1 cm)	Conditionally fit	If LV size/function are normal, with follow-up. Class 2 OSL.
Aortic root dilatation (>4.0 cm)	Conditionally fit	If LV size/function are normal, with annual cardiac follow-up. Class 1 OML, Class 2 OSL.
Aortic root dilatation (>5.0 cm)	Unfit	Disqualified
LVEDD >6.0 cm	Unfit	Disqualified

AME, aeromedical examiner; AMS, Aeromedical Section; AVAI, aortic valve area index; BNP, brain natriuretic peptide; EF, ejection fraction; LAPL, Light Aircraft Pilot Licence; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; OML, operational multi-crew limitation; OPL, operational pilot limitation; ORL, operational restriction limitation; OSL, operational safety limitation; SSL, special skill limitation.

an operational safety limitation (OSL) following specialist cardiological assessment.[25,29]

Mitral Regurgitation

Regarding mitral regurgitation and mitral valve prolapse, an isolated mid-systolic click is considered benign and warrants an unrestricted fit assessment.[2,25] Minor mitral regurgitation is also compatible with unrestricted fitness, contingent upon the absence of thickened leaflets or flail chordae and a left atrial diameter of 4 cm or less.[25] Moderate mitral regurgitation necessitates operational restrictions, specifically an OML for Class 1 applicants and an ORL or OSL for Class 2 applicants.[25] Certification for this condition requires the absence of left ventricular enlargement, satisfactory exercise stress testing, and periodic cardiological follow-up including echocardiography, exercise testing, and Holter monitoring.[2,25] Conversely, ischemic mitral regurgitation and severe mitral regurgitation are considered incompatible with certification.[2,25] Applicants should also be considered unfit if progressive chamber remodeling is present, including LV end-diastolic diameter >6.0 cm, LV end-systolic diameter >4.1 cm, or left atrial diameter >4.5 cm.[25] Likewise, the presence of AF, previous transient ischemic attack (TIA), systemic embolism, or documented left ventricular dysfunction precludes unrestricted certification.[2,25,29] Aircrew with mitral valve disease must be evaluated according to these specified criteria (Table 11).

Fitness After Valve Surgery

Aeromedical assessment after valve repair or replacement must be especially cautious because postoperative patients may remain at risk of prosthetic dysfunction, residual regurgitation or stenosis, thromboembolism, bleeding complications related to anticoagulation, ventricular dysfunction, arrhythmias, and progressive chamber enlargement. Accordingly, return to flight should never be based solely on the elapsed time after surgery, but rather on a comprehensive demonstration of clinical stability, satisfactory imaging findings, acceptable functional capacity, and low procedural or pharmacological risk.[2,7,24]

For Class 1 licence holders, applicants are considered initially unfit after valve repair or valve replacement. Reconsideration for certification should generally not occur before 6 months after surgery, and only if the individual is asymptomatic and all relevant cardiological and aeromedical criteria are satisfied.[2,6] After mitral valve prolapse repair, return to flight may be considered only when left ventricular size and systolic function are normal, there is no relevant chamber dilatation, and any residual mitral regurgitation is no more than trivial.[2,7,24]

In individuals with tissue or mechanical prosthetic valves, return to flight may be considered at ≥6 months postoperatively if there is no significant prosthetic valve dysfunction, ventricular size and function are normal, and no relevant cardioactive medication is required beyond treatment judged compatible with aviation safety.[2,7,24] If anticoagulation is required, certification may still be possible with OML (Operational Multi-crew Limitation), provided that hemorrhagic risk is considered acceptable and anticoagulation is demonstrably stable. A practical stability definition is that at least 4 of the last 5 INR

Table 11. Mitral Valve Diseases and Flight Fitness

Clinical Condition	Flight Fitness	Possible Limitations
Rheumatic mitral valve		
Rheumatic mitral stenosis and/or regurgitation	Unfit	Disqualified
Minor mitral leaflet tethering	Conditionally fit	Class 1 with OML if in sinus rhythm and without LA enlargement.
Mild mitral stenosis (valve area >2 cm^2)	Conditionally fit	Class 2 with OSL limitation
Mitral regurgitation/mitral valve prolapse		
Isolated mid-systolic click	Fit	None
Ischemic mitral regurgitation	Unfit	Disqualified
Minor mitral regurgitation	Fit	If no thickened leaflets or flail chordae are present and LA diameter is ≤4 cm.
Moderate mitral regurgitation	Conditionally fit	Class 1 (OML) or Class 2 (ORL/OSL) if there is no LV enlargement, exercise test is normal, and annual follow-up with echocardiography, stress testing, and Holter monitoring is maintained.
Severe mitral regurgitation	Unfit	Disqualified
LVEDD >6 cm)	Unfit	Disqualified
LVESD >4.1 cm	Unfit	Disqualified
Left atrial inner diameter >4.5 cm	Unfit	Disqualified
Atrial fibrillation	Unfit	Disqualified
History of TIA	Unfit	Disqualified
LV dysfunction	Unfit	Disqualified

AMS, Aeromedical Section; Echo, echocardiography; LV, left ventricular; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; OML, operational multi-crew limitation; ORL, operational restriction limitation; OSL, operational safety limitation; TIA, transient ischemic attack.

measurements must have remained within the therapeutic target range over a 6-month period.[2,7] Exercise capacity should be documented by a symptom-limited exercise test; when exercise ECG is non-diagnostic or abnormal, stress imaging should be used instead. A 2D Doppler echocardiographic examination must confirm the absence of significant chamber enlargement and show only minimal or acceptable prosthetic valve-related changes.[2,7,24] The frequency and extent of further follow-up should be determined by the AMS according to valve type, anticoagulation status, ventricular function, and overall clinical course.[2,7]

For Class 2 license holders, the postoperative approach is somewhat more flexible. If there is no ongoing need for anticoagulation, certification may be granted without limitation after satisfactory cardiological and aeromedical evaluation.[2,7] If anticoagulation is required, and bleeding risk is judged acceptable with documented treatment stability, ORL/OSL limitations may be applied.[2,7] In selected cases, near-patient INR testing performed within 12 hours before flight, together with flight only when INR is within the therapeutic range, may support certification without those limitations.[2,7] For anticoagulants that do not require INR monitoring, certification may be considered after a 3-month stabilization period, provided consultation with the AMS confirms acceptable safety and absence of treatment-related complications.[2,7]

Situations Incompatible with Flight Clearance After Valve Surgery

Patients with mechanical valve replacement should be regarded as unfit for flight within the first 3-6 months after surgery, in the presence of symptoms, when left ventricular ejection fraction is below 50%, when there is a history of thromboembolic complications, when echocardiographically determined pulmonary hypertension is present, or when stable and adequate anticoagulation cannot be maintained and regular INR monitoring is not feasible.[2,7,24] Likewise, flight clearance should not be granted in cases of uncorrected prosthetic valve dysfunction, including significant prosthetic stenosis, regurgitation, paravalvular leak, or prosthetic thrombosis.[7,24] These considerations are particularly important in Class 1 operational settings, where the aeromedical tolerance for hemodynamic instability or embolic/hemorrhagic risk is especially low.[2,7]

Practical Aeromedical Interpretation

From an aeromedical standpoint, postoperative valve patients may be considered for certification only when the following conditions are met: durable symptom-free status, preserved ventricular function, satisfactory prosthetic or repaired valve performance, acceptable exercise tolerance, absence of major arrhythmia, and stable anticoagulation when required.[2,7,24] Mechanical prostheses and anticoagulation do not automatically preclude certification, but they substantially increase the scrutiny required and usually necessitate an operational limitation in higher-risk licence classes.[2,7] Conversely, symptomatic postoperative status, depressed ventricular function, persistent pulmonary hypertension, embolic history, unstable anticoagulation, or unresolved prosthetic dysfunction should be regarded as disqualifying findings.[2,7,24] Specific conditions related to valve surgery are presented in Table 12.

AORTIC DISEASE AND ANEURYSMS

Aeromedical assessment of applicants with thoracic or abdominal aortic aneurysms should follow the principles

Table 12. Valve Surgery and Fitness for Flying

Clinical Condition	Flight Fitness	Possible Limitations
Mitral valve repair	Conditionally fit	Class 1, OML, if LV function is normal, without systolic or diastolic dilatation, and residual MR is no more than mild.
	Fit	Class 2, None, If anticoagulation is not required and evaluation is satisfactory.
Tissue or mechanical valve	Conditionally fit	Class 1 OML, Class 2 ORL/OSL if off cardioactive medication, with normal valve function and normal ventricular function/ configuration.
	Fit	Class 2, no restriction if anticoagulation is not required
Those requiring anticoagulation	Conditionally fit	Class 1 OML, Class 2 ORL/OSL if hemorrhagic risk is acceptable and anticoagulation is stable.
	Fit	Class 2, no restriction may be needed if near-patient testing is used.
<6 months post-surgery, symptoms, LVEF <50%, prosthetic valve dysfunction, thromboembolism, pulmonary hypertension, unstable anticoagulation/INR, significant ventricular dysfunction or chamber enlargement, or clinically significant arrhythmias.	Unfit	Disqualified

INR, international normalized ratio; LV, left ventricle; LVEF, left ventricular ejection fraction; OML, operational multi-crew limitation; ORL, operational restriction limitation; OSL, operational safety limitation.

outlined in the 2024 ESC Guidelines for the Management of Peripheral Arterial and Aortic Diseases, which, for the first time, integrate peripheral arterial and aortic diseases within a single guideline framework.[30] In addition, certification decisions should comply with the EASA, Easy Access Rules for Aircrew (Part-MED), which provide specific recommendations regarding aeromedical certification of applicants with aortic aneurysms.[2] Aeromedical certification should be based primarily on maximal aortic diameter, aneurysm location (thoracic, supra-renal, or infra-renal abdominal), growth rate, repair status, blood-pressure control, clinical stability, and the presence of associated valvular or connective tissue disorders, as acute aortic dissection or rupture during flight represents an unacceptable catastrophic risk.[2,30] According to EASA, infra-renal abdominal aortic aneurysms <5 cm may be considered fit before surgery for Class 1 applicants with an OML, provided serial imaging and cardiological follow-up are satisfactory, whereas thoracic or supra-renal abdominal aneurysms <5 cm may be considered for lower license classes with appropriate operational restrictions such as ORL or OSL following satisfactory cardiovascular assessment.[2] Applicants with an aortic diameter <40 mm are generally considered fit for all license classes. At diameters of 40-44 mm, certification becomes conditional, with Class 1 applicants requiring a SIC and Class 2, LAPL, and Class 3 applicants generally requiring a TML and periodic cardiological reassessment. When the aortic diameter reaches 45-49 mm, more stringent operational restrictions are required because of the increased risk of progressive dilatation and acute aortic events.[2,30] Class 1 applicants may only be considered conditionally fit with OML, TML, and SSL, whereas Class 2 and LAPL applicants require OSL, ORL, OPL, TML, and SSL. Class 3 applicants may be considered conditionally fit with TML and SSL. Applicants with an aortic diameter ≥50 mm, rapidly enlarging, symptomatic, or otherwise high-risk aneurysms should be considered unfit for all certification classes because the risk of dissection or rupture is incompatible with safe flight operations.[2,30] Following successful surgical repair of thoracic or abdominal aortic aneurysms, recertification may be considered after comprehensive cardiological and aeromedical evaluation. In such cases, applicants may be assessed as conditionally fit, generally with OML and SSL, provided postoperative recovery is complete, imaging confirms a stable repair without significant residual pathology, ventricular function is preserved, blood pressure is adequately controlled, and long-term surveillance demonstrates sustained clinical stability.[2,30] Table 13 presents the general rules for the assessment of aircrew with aortic aneurysms.

CONGENITAL HEART DISEASE

In aviation medicine, congenital heart disease cannot be assessed solely according to the anatomical diagnosis. Instead, aeromedical certification should be based on a comprehensive assessment of hemodynamic significance, ventricular size and function, pulmonary artery pressure, residual shunting, arrhythmia burden, thromboembolic risk, exercise capacity, and the long-term outcome following surgical or transcatheter repair.[2,6,31] Accordingly, simple congenital defects that are completely repaired or remain hemodynamically insignificant may be compatible with medical certification, whereas cyanotic congenital heart disease, Eisenmenger syndrome, pulmonary hypertension, significant residual shunts, ventricular dysfunction, heart failure, or clinically significant atrial or ventricular arrhythmias generally represent conditions incompatible with aviation duties because of their potential to cause progressive cardiovascular deterioration or sudden in-flight incapacitation (Table 14).[2,6,31]

Applicants with isolated atrial septal defect (ASD), ventricular septal defect (VSD), patent ductus arteriosus (PDA), selected repaired coarctation of the aorta, or asymptomatic patent foramen ovale (PFO) may be considered individually when

Table 13. Assessment of Aircrew with Thoracic and Abdominal Aortic Aneurysms

Clinical Condition	Flight Fitness	Possible Limitations
Thoracic or abdominal aorta <40 mm	Fit	Certification in all classes if asymptomatic, blood pressure is well controlled, and serial imaging demonstrates stability.
Thoracic or abdominal aorta 40-44 mm	Conditionally fit	TML or SIC depending on licence class. Requires regular imaging surveillance, strict blood-pressure control, and no evidence of rapid enlargement.
Thoracic or abdominal aorta 45-49 mm	Conditionally fit	Class 1: OML + TML + SSL. Class 2/LAPL: OSL/ORL/OPL + TML + SSL. Class 3: TML + SSL. Certification only if stable, asymptomatic, and without rapid aneurysm growth.
Thoracic or abdominal aorta ≥50 mm	Unfit	Disqualified
After successful surgical repair	Conditionally fit	May be reconsidered following satisfactory cardiovascular and aeromedical evaluation. OML/SSL generally appropriate for Class 1; restrictions depend on postoperative imaging, ventricular function, blood-pressure control, and absence of complications.

OML, operational multi-crew limitation; OPL, operational pilot limitation; ORL, operational restriction limitation; OSL, operational safety pilot limitation; SIC, specific regular medical examination(s); SSL, special safety pilot limitation (requires presence of a safety pilot); TML, time-limited medical certificate.

Table 14. Congenital Heart Diseases and Fitness for Flight

Clinical Condition	Flight Fitness	Possible Limitations
Isolated ASD		
Small secundum ASD	Fit	No restriction if Qp/Qs <1.5, normal RV/PA pressures, normal Holter, no associated anomaly, and periodic cardiac follow-up.
Early closed secundum ASD	Fit	
Late closed secundum ASD	Conditionally fit	Class 1 OML
Small or corrected ostium primum type ASD	Conditionally fit	Class 1 OML
Sinus venosus type ASD (very small or corrected)	Conditionally fit	Class 1 OML
Uncorrected large ASD	Unfit	Disqualified
Presence of atrial fibrillation	Unfit	Disqualified
Isolated ventricular septal defect (VSD)		
Small VSD (Qp/Qs < 1.5:1)	Fit	No restriction if no cardiomegaly, no pulmonary hypertension, and periodic cardiac evaluation is maintained.
Early closed VSD	Fit	
Spontaneously closed VSD	Fit	
VSD, that are large and unrepaired, associated with significant arrhythmias, or persisting with complications after surgery	Unfit	Disqualified
Isolated pulmonary stenosis		
Pulmonary valvular stenosis (gradient <20 mm Hg)	Fit	No restriction if no right ventricular hypertrophy, tricuspid velocity <2.5 m/s and annual cardiac evaluation maintained.
Pulmonary valvular stenosis (gradient: 20–30 mm Hg)	Conditionally fit	Class 1 OML
Corrected infundibular stenosis	Individual assessment	
Supravalvular stenosis	Unfit	Disqualified
Isolated PDA		
Closed PDA	Fit	No restriction if no pulmonary hypertension and periodic cardiac evaluation is maintained.
Unclosed small PDA	Conditionally fit	Class 1 OML
Isolated aortic coarctation		
Early corrected aortic coarctation (<12 years)	Fit	No restrictions if normotensive with periodic follow-up.
Late corrected coarctation	Conditionally fit	Class 1 certification may be considered with OML if hypertension is controlled and periodic follow-up is maintained.
TOF		
Early operated TOF	Conditionally fit	Class 1 certification with OML may be considered if there is no residual right ventricular hypertrophy, no significant pulmonary regurgitation, no complex ventricular arrhythmia, and periodic cardiac evaluation is maintained.
PFO		
Asymptomatic PFO	Fit	None
PFO closed after TIA	Fit	Unrestricted certification may be considered 1 year after successful closure.

AME, aeromedical examiner; AMS, Aeromedical Section; ASD, atrial septal defect; EF, ejection fraction; OML, operational multi-crew limitation; PDA, patent ductus arteriosus; PFO, patent foramen ovale; Qp/Qs, pulmonary-to-systemic flow ratio; TIA, transient ischemic attack; TOF, Tetralogy of Fallot; VSD, ventricular septal defect.

complete anatomical correction has been achieved and no residual hemodynamic or electrophysiological abnormalities are present. In contrast, complex congenital heart disease—including repaired Tetralogy of Fallot with residual lesions, Fontan circulation, systemic right ventricle, Eisenmenger physiology, or congenital lesions associated with persistent right ventricular volume or pressure overload—usually requires a more restrictive aeromedical assessment because of the increased lifetime risk of arrhythmia, ventricular dysfunction, heart failure, and thromboembolic complications.[2,6,31] Aeromedical evaluation should be individualized and performed by a cardiologist experienced in adult congenital heart disease in collaboration with the aeromedical medical examiner (AME) or Aeromedical Centre (AeMC). Standard investigations include transthoracic Doppler echocardiography, maximal symptom-limited exercise

testing, and 24-hour ambulatory ECG monitoring. Cardiac magnetic resonance imaging, computed tomography, cardiopulmonary exercise testing, or additional investigations should be performed whenever structural complexity or residual hemodynamic abnormalities cannot be adequately characterized by routine assessment.[2,6,31]

Certification may be considered only in applicants with complete repair or hemodynamically insignificant lesions, preserved biventricular function, normal pulmonary artery pressure, absence of clinically significant arrhythmias, no requirement for cardioactive medication, and satisfactory exercise capacity without evidence of myocardial ischemia or hemodynamic limitation.[2,6,31,32] Periodic cardiological surveillance, including serial echocardiography and ambulatory rhythm monitoring, is recommended because late complications may develop even after apparently successful repair.[2,6,31]

Applicants with cyanosis, pulmonary hypertension, significant residual shunts, ventricular dysfunction, recurrent supraventricular or ventricular arrhythmias, heart failure, or other complex congenital physiology should generally be considered unfit for unrestricted aviation duties.[2,6] For Class 1 applicants, assessment by the licensing authority or AMS is required, whereas Class 2 applicants should undergo specialist cardiological evaluation in consultation with the AMS before certification is considered.[2]

Although many congenital cardiac conditions are compatible with long-term survival and good functional capacity, flight certification is generally reserved for individuals with the most favorable hemodynamic profiles and the lowest predicted risk of sudden incapacitation.

Atrial Septal Defect

Atrial septal defect is among the most frequently encountered congenital lesions in adult aeromedical evaluation. Small isolated secundum ASDs with a pulmonary-to-systemic flow ratio (Qp/Qs) below 1.5 may allow unrestricted certification provided that right ventricular size and pulmonary artery pressures remain normal. Similarly, defects closed early in life with no residual hemodynamic consequences may permit unrestricted certification.[8,31]

When ASD closure occurs later in life, Class 1 certification may still be considered but generally requires an OML because of the potential long-term risk of atrial arrhythmias. Elevated right ventricular or pulmonary artery pressures and the presence of atrial arrhythmias such as AF or flutter represent disqualifying findings.[2,8,31]

Less common ASD variants require careful evaluation. Ostium primum defects may permit certification with OML when mitral regurgitation is minimal or absent, pulmonary pressures are normal, and ambulatory rhythm monitoring shows no clinically significant arrhythmia. Sinus venosus defects may also permit Class 1 certification with OML when rhythm monitoring is normal, although annual echocardiographic and Holter monitoring follow-up is required.[2,8,31]

Ventricular Septal Defect

Isolated small VSDs without evidence of cardiomegaly or pulmonary hypertension are usually compatible with aviation duties. Individuals with Qp/Qs ratios below 1.5:1, normal cardiac chamber dimensions, and normal pulmonary artery pressures may receive unrestricted certification. Similarly, defects that were successfully closed in early childhood without residual hemodynamic consequences may permit certification without limitation.[2,8,31]

Pulmonary Stenosis

Mild valvular pulmonary stenosis is generally compatible with aviation duties provided that right ventricular hypertrophy is absent and the peak-to-peak transvalvular gradient remains below approximately 20 mmHg. Gradients between 20 and 30 mmHg may still permit Class 1 certification with OML, depending on overall hemodynamic stability and absence of right ventricular dysfunction.[2,8,31] Individuals who have undergone surgical correction of subvalvular pulmonary stenosis may also be considered for certification following satisfactory cardiological evaluation. In contrast, supravalvular pulmonary stenosis involving the pulmonary trunk or branch pulmonary arteries, particularly when associated with multiple structural abnormalities, is generally considered disqualifying because of the potential for progressive hemodynamic compromise.[2,8,31]

Patent Ductus Arteriosus

Following successful closure of an isolated PDA, certification may be granted if the original shunt was not hemodynamically significant and pulmonary hypertension is absent. Individuals with a small unrepaired isolated PDA may occasionally receive Class 1 certification with OML, provided that there is no evidence of ventricular enlargement, pulmonary hypertension, or arrhythmia.[2,8,31]

Coarctation of the Aorta

Individuals with coarctation of the aorta repaired before the age of 12 years may be considered fit for aviation duties if they remain normotensive both at rest and during exercise. Late repair may be associated with persistent hypertension, and in such cases, limited certification may be possible only with careful blood-pressure monitoring and regular cardiological follow-up.[2,8,31] Because BAV frequently coexists with coarctation, echocardiographic surveillance of the aortic root and ascending aorta is essential. Ascending aortic dilation is incompatible with aviation certification due to the potential risk of progressive enlargement or dissection.[2,8,31]

Tetralogy of Fallot

Individuals with Tetralogy of Fallot repaired in early childhood, particularly before the age of 12 years, may be considered for limited certification when no significant residual right ventricular hypertrophy, pulmonary regurgitation, or clinically relevant ventricular arrhythmias are present. Regular cardiological follow-up is essential because late complications such as right ventricular dilation, pulmonary regurgitation, and ventricular tachyarrhythmias are well recognized in adult survivors of TOF repair.[2,7,30] Outcomes tend to be less favorable when repair occurs later

in life, and the risk of arrhythmias and sudden cardiac death is correspondingly higher.[31]

Patent Foramen Ovale

An asymptomatic PFO is generally considered compatible with unrestricted aviation duties. However, when a transient ischemic attack or cryptogenic stroke has occurred, certification may only be reconsidered after successful closure of the defect and a stable follow-up period of approximately 1 year, provided that no recurrent neurological or cardiovascular complications are identified.[2,8,31,33]

VENOUS THROMBOEMBOLISM AND PREVENTION OF DEEP VEIN THROMBOSIS/PULMONARY EMBOLISM IN AIRCREW

Long-duration travel is a recognized VTE risk amplifier, and pilots or cabin crew may be exposed to prolonged sitting, dehydration, circadian disruption, and interacting risk factors such as age, obesity, recent surgery, thrombophilia, cancer, estrogen exposure, or prior VTE. The current ESC pulmonary embolism reference in force is the 2019 PE guideline.

Non-pharmacological measures form the basis of VTE prevention during long-duration flights and include regular ambulation, adequate hydration, avoidance of prolonged immobility, and the use of compression stockings in selected high-risk individuals. Individuals with recent DVT or PE should not fly until diagnosis, treatment, hemodynamic recovery, anticoagulation stability, and specialist clearance are complete. This is especially important because post-PE dyspnea, recurrence risk, and anticoagulant-related bleeding all have operational relevance. The FAA anticoagulation materials also underscore that the underlying condition and stability of therapy determine certification. Table 15 summarizes practical recommendations for the prevention of travel-related VTE and the aeromedical management of aircrew at increased thromboembolic risk.

CARDIOVASCULAR DRUG USE IN AIRCREW

Medication use in aircrew represents a critical component of aeromedical evaluation because pharmacological therapy itself may influence operational safety (Table 16). Although many cardiovascular conditions can be effectively treated with modern medical therapy, certain medications may impair cognitive performance, hemodynamic stability, or reaction time and thereby limit an individual's ability to safely perform flight duties. Consequently, aeromedical drug assessment is considered as important as the evaluation of the underlying disease.[2,8] A medication that is therapeutically appropriate in routine cardiology practice may still be operationally unacceptable in aviation if it produces sedation, orthostatic hypotension, cognitive slowing, urinary urgency, visual disturbance, or unpredictable metabolic effects, including fluctuations in blood glucose levels. Therefore, aviation medicine authorities require careful assessment of the pharmacodynamic and side-effect profile of cardiovascular medications, in addition to evaluating the stability of the treated condition.[2,8] Aeromedical regulatory frameworks such as EASA Part-MED and FAA

Table 15. Deep Vein Thrombosis and Pulmonary Thromboembolism: Aeromedical Recommendations for Aircrew

Category	Recommendation/Explanation	Target Group
Flight duration and position	For flights longer than 4 hours, it is recommended to move for at least 5 minutes every hour. Cockpit crew should take a short walk every 2 hours.	Pilots
Cabin mobility	Cabin crew are naturally mobile; however, they should avoid sitting for long periods during off-duty.	Cabin crew
Risk factor screening	During annual health checkups, personal or family history of VTE should be questioned. D-dimer testing and venous Doppler ultrasonography may be considered when clinically indicated.	All aircrew
Hydration	Adequate fluid intake should be ensured before and during flight. Caffeine and alcohol should be avoided.	All aircrew
Clothing and equipment	Avoid tight belts or garments compressing below the knee. On the day of flight, compression stockings are recommended especially for at-risk individuals.	Age >50/at-risk individuals
Medication (prophylaxis)	Pharmacological prophylaxis should not be used routinely. LMWH may be considered in selected individuals at very high thromboembolic risk following individualized medical assessment. Aspirin should not be prescribed solely for the prevention of travel-related VTE.	Selected aircrew
Hypobaric hypoxia risk	In conditions such as heart failure/COPD, oxygen saturation should be checked before flight. Hypoxia simulation should be performed if necessary.	Individuals with chronic diseases
Education and awareness	Aircrew should receive VTE awareness training at least once a year. Training on early symptom recognition should be provided.	All aircrew
Pre-flight checklist additions	"Leg swelling, pain, shortness of breath" symptoms should be added to the pre-flight health checklist.	All aircrew
Flight suspension conditions	Aircrew with acute DVT/PTE should refrain from flying for at least 6 weeks. Return to flight requires approval from hematology/cardiology.	Aircrew with acute VTE

ACCP, American College of Chest Physicians; ASA, acetylsalicylic acid; COPD, chronic obstructive pulmonary disease; DVT, deep vein thrombosis; EASA, European Union Aviation Safety Agency; ESC, European Society of Cardiology; LMWH, low-molecular-weight heparin; PTE, pulmonary thromboembolism; VTE, venous thromboembolism.

Table 16. Evaluation of Aircrew Using Cardiovascular Drugs

Antihypertensives	Beta-blockers	Fit (metoprolol, carvedilol, bisoprolol, atenolol, pindolol, propranolol, labetalol)
	Calcium-channel blockers	Fit (amlodipine, nifedipine, nicardipine, benidipine, felodipine, lacidipine, diltiazem, verapamil)
	Angiotensin receptor blockers	Fit (valsartan, losartan, irbesartan, olmesartan, candesartan, telmisartan)
	ACE inhibitors	Fit (ramipril, lisinopril, captopril, perindopril, zofenopril, trandolapril, quinapril)
	Alpha blockers	Fit (doxazosin, prazosin)
	Diuretics	Fit (hydrochlorothiazide, furosemide, torasemide, bumetanide, triamterene, amiloride)
	Mineralocorticoid Inhibitors	Fit (spironolactone, eplerenone)
	Centrally acting agents	Unfit (clonidine, methyldopa)
Heart failure drugs	ARNI	After specialist review sacubitril
	SGLT-2 inhibitors	After specialist review (dapagliflozin, empagliflozin)
	Digitalis	After specialist review (digoxin)
Coronary artery disease treatment	Antiplatelet therapy	Fit (aspirin, clopidogrel)
		After specialist review (prasugrel, ticagrelor)
	Coronary vasodilators/anti-ischemic drugs	Unfit (nitrates and ranolazine)
Arrhythmia treatment	Antiarrhythmic drugs	After specialist review (disopyramide, procainamide, mexiletine, flecainide, propafenone, sotalol, dronedarone, amiodarone [max 200 mg])
	Anticoagulants	After specialist review (warfarin, apixaban, rivaroxaban, edoxaban)
Hyperlipidemia treatment	Statins	Fit (atorvastatin, rosuvastatin, pitavastatin, simvastatin, fluvastatin)
	Fibrates	Fit (fenofibrate, gemfibrozil)

ACE, angiotensin-converting enzyme; ARNI, angiotensin receptor–neprilysin inhibitor; SGLT-2, sodium–glucose cotransporter-2.

aeromedical guidance emphasize that pharmacological treatment must always be interpreted within the context of the underlying cardiovascular disorder. For example, antihypertensive therapy may be acceptable when blood pressure is well controlled and medication is well tolerated, whereas treatment for unstable heart failure or active ischemia generally indicates a disease state incompatible with flight duties.[2,8] A practical aeromedical principle is that initiation of a new cardiovascular medication or any dose adjustment should result in a temporary grounding period until tolerability and hemodynamic stability are documented. This observation period allows detection of potential side effects such as hypotension, bradycardia, dizziness, or cognitive impairment that may interfere with flight performance. The required observation period varies according to the regulatory authority. Current FAA guidance requires a 7-day no-fly/ground trial following initiation of a new antihypertensive medication to verify the absence of adverse effects, whereas EASA guidance recommends that applicants initiating antihypertensive therapy be assessed as unfit until the absence of significant side effects has been established.[2,8] In general, ACE inhibitors, angiotensin receptor blockers (ARBs), beta-blockers, calcium-channel blockers, thiazide diuretics, statins, and selected antiplatelet agents are frequently compatible with aeromedical certification when the underlying cardiovascular condition is stable and medication is well tolerated.[2,8]

Federal Aviation Administration guidance identifies several antihypertensive drug classes—including ACE inhibitors, angiotensin II receptor blockers (ARBs), beta-adrenergic blockers, calcium-channel blockers, diuretics, alpha-adrenergic blockers, direct renin inhibitors, and direct vasodilators—as acceptable when certification criteria are met. In contrast, clonidine, guanabenz, guanfacine, methyldopa, reserpine, and nitrates are specifically listed as unacceptable for the treatment of hypertension.[8] FAA aeromedical policies similarly address medication acceptability within structured disease-disposition frameworks. Conditions such as CAD, AF, anticoagulation therapy, and diabetes mellitus are evaluated through dedicated aeromedical decision pathways, often involving special issuance certification when the treated condition demonstrates long-term stability.[8]

Antihypertensive Therapy

Antihypertensive therapy is one of the most commonly encountered pharmacological treatments among aircrew. Initiation of antihypertensive medication or a clinically relevant modification of therapy requires a period of temporary grounding to assess tolerability and exclude adverse effects that may compromise flight safety. Current

FAA guidance requires a 7-day no-fly/ground trial after initiation of a new antihypertensive medication, while EASA guidance recommends that applicants initiating blood-pressure–lowering medication be assessed as unfit until the absence of significant side effects has been established. Return to flight duties should therefore be considered only after satisfactory aeromedical evaluation and confirmation that blood-pressure control is stable and treatment is well tolerated.[2,8]

Major Antihypertensive Drug Classes

Several antihypertensive drug classes are generally considered compatible with aviation duties when well tolerated and when the underlying hypertension remains adequately controlled.[2,8,34]

Beta-blockers may be acceptable in appropriately selected aircrew provided that excessive bradycardia, fatigue, hypotension, or exercise intolerance does not occur. European Union Aviation Safety Agency guidance specifically recognizes certain, generally hydrophilic, beta-blocking agents as acceptable options, while FAA guidance also includes beta-adrenergic blockers among acceptable antihypertensive drug classes when certification criteria are met.[2,8]

Calcium-channel blockers are similarly accepted by both EASA and FAA as potential antihypertensive therapy in aircrew, provided that treatment is effective and does not produce clinically significant adverse effects.[2,8]

Angiotensin-converting enzyme inhibitors and angiotensin II receptor blockers (ARBs) are explicitly included among acceptable antihypertensive drug classes in both EASA and FAA aeromedical guidance.[2,8]

Alpha-adrenergic blockers may also be acceptable under FAA guidance, provided that treatment is well tolerated and certification criteria are fulfilled. Particular attention should be paid to orthostatic hypotension and related symptoms that could impair operational performance.[8]

Diuretics are considered acceptable within FAA guidance, whereas EASA specifically identifies non-loop diuretic agents as acceptable antihypertensive therapy. In all cases, adequate hydration, electrolyte balance, renal function, and the absence of clinically significant adverse effects should be established.[2,8]

By contrast, several centrally acting antihypertensive agents are considered aeromedically problematic. FAA guidance specifically lists clonidine, guanabenz, guanfacine, methyldopa, and reserpine, as well as nitrates used for the treatment of hypertension, as unacceptable medications for medical certification.[8] Aircrew starting any antihypertensive therapy should undergo an appropriate period of aeromedical observation to confirm efficacy and the absence of significant adverse effects before returning to flight duties.[2,8,34]

Pharmacological Therapy in Heart Failure

Most individuals with symptomatic congestive heart failure are considered unfit for aviation duties because of the risk of hemodynamic instability and arrhythmia. Nevertheless, when heart failure is mild, well controlled, and stable under specialist supervision, pharmacological therapy may be compatible with restricted certification following comprehensive cardiological assessment.[2,8]

Major Heart Failure Medications

Angiotensin receptor–neprilysin inhibitors (ARNIs), particularly sacubitril/valsartan, constitute an established component of guideline-directed medical therapy for heart failure with reduced ejection fraction.[35] From an aeromedical perspective, their use should be evaluated individually, with particular attention to blood pressure, renal function, electrolyte balance, functional capacity, and the stability of the underlying cardiac disease.[2,8,35]

Sodium–glucose cotransporter-2 (SGLT2) inhibitors, including dapagliflozin and empagliflozin, are established components of contemporary heart failure therapy and reduce the risk of heart failure hospitalization and cardiovascular events in appropriately selected patients.[34] In aircrew, their use requires individualized aeromedical assessment, including evaluation for volume depletion, hypotension, renal dysfunction, and metabolic adverse effects that could potentially affect operational safety.[2,8,35]

Digoxin may be used in selected patients with heart failure or for ventricular rate control in AF according to clinical indications.[35] In an aeromedical setting, particular consideration should be given to renal function, serum drug concentrations when clinically indicated, cardiac rhythm, conduction abnormalities, and the potential for toxicity.[2,8,35]

Importantly, the requirement for advanced heart failure pharmacotherapy may indicate significant underlying structural or functional cardiac disease. Aeromedical fitness should therefore be determined primarily by the severity and stability of the cardiovascular disorder, ventricular function, arrhythmic risk, exercise capacity, and treatment tolerability rather than by medication use alone.[2,8]

Pharmacological Therapy in Coronary Artery Disease

Pharmacological therapy is a central component of the long-term management of CAD in aircrew. From an aeromedical perspective, however, cardiovascular medication should not be assessed solely according to whether a particular drug is considered acceptable or unacceptable for flight duties. The indication for treatment, the stability of the underlying coronary disease, the presence or absence of myocardial ischemia, residual coronary atherosclerotic burden, ventricular function, exercise capacity, treatment efficacy, adverse effects, bleeding risk, and the probability of future acute coronary events must all be considered together. The principal pharmacological objectives in aircrew with established CAD are prevention of coronary thrombosis, stabilization of atherosclerotic plaque, reduction of recurrent cardiovascular events, optimization of blood pressure and ventricular workload, and control of other modifiable cardiovascular risk factors. In contrast, medication that is required primarily to suppress ongoing myocardial ischemia or anginal symptoms has substantially different aeromedical implications because dependence on

chronic anti-anginal treatment may indicate persistence of clinically relevant coronary disease.[2,8,36]

Accordingly, CAD medications can be considered aeromedically within 2 broad categories: secondary-prevention therapies, which reduce future cardiovascular risk, and symptom-controlling anti-ischemic therapies, which may indicate continuing active disease. This distinction is especially important in aviation medicine because successful suppression of symptoms does not necessarily indicate that the underlying coronary substrate has become sufficiently low risk for unrestricted flight duties.[2,36]

Antiplatelet Therapy

Antiplatelet therapy is a cornerstone of secondary prevention in patients with established CAD, previous myocardial infarction, and following coronary revascularization. Aspirin, and where clinically indicated additional antiplatelet therapy, reduces the risk of recurrent coronary thrombosis and forms part of standard secondary-prevention treatment following coronary events or PCI.[2,8] From an aeromedical perspective, antiplatelet therapy itself should generally be interpreted as a marker of the underlying cardiovascular condition rather than as an isolated reason for disqualification. The aeromedical assessment should therefore establish why antiplatelet treatment is required, whether the coronary disease is clinically stable, whether myocardial ischemia has been adequately excluded, whether ventricular function is preserved, and whether there has been any clinically significant hemorrhagic complication.[2,8] The bleeding risk associated with antiplatelet therapy is particularly relevant in aircrew because even relatively minor hemorrhagic events may have operational consequences in certain flight environments. Nevertheless, the presence of antiplatelet therapy does not by itself imply unacceptable aeromedical risk when treatment is stable and well tolerated. Conversely, recurrent gastrointestinal bleeding, intracranial hemorrhage, significant anemia, or any bleeding episode requiring medical intervention should prompt reconsideration of fitness and further aeromedical review.[8] Following PCI, the requirement for dual antiplatelet therapy should be considered in the context of the indication for intervention, the time elapsed since revascularization, treatment stability, absence of recurrent ischemia, and overall bleeding risk. The completion of a clinically appropriate antiplatelet regimen does not in itself establish fitness to fly; return to duties remains dependent on satisfactory clinical, anatomical, and functional reassessment.[2,8] Thus, in aircrew receiving antiplatelet agents, the critical aeromedical questions are not simply whether aspirin or another antiplatelet drug is being used, but whether treatment is effective, stable, free of clinically significant adverse effects, and associated with a sufficiently low residual risk of coronary thrombosis or incapacitating bleeding.[2,8,36]

Lipid-Lowering Therapy

Aggressive lipid-lowering therapy is one of the most important pharmacological strategies for aircrew with established coronary atherosclerosis. Its aeromedical relevance is particularly high because the objective is not merely reduction of serum cholesterol but stabilization of coronary plaque, limitation of atherosclerotic progression, and reduction of the probability of future ACSs. Statin therapy should therefore be regarded as an important component of secondary prevention in aircrew with CAD. Davenport et al. emphasized that aggressive modification of cardiovascular risk factors is essential in aviation personnel with documented coronary atherosclerosis, including individuals with non-obstructive disease.[36] The aeromedical significance of lipid-lowering therapy is particularly important because non-obstructive coronary disease should not be regarded as benign. Acute coronary events may arise from previously non-severe plaques, and future risk relates not only to the severity of the largest individual stenosis but also to the overall atherosclerotic burden. Consequently, effective lipid-lowering therapy may contribute substantially to long-term risk reduction even in aircrew without hemodynamically significant coronary stenosis.[36] Davenport et al[36] incorporated aggressive LDL reduction into an overall strategy of cardiovascular risk optimization. In their aviation cardiology framework, an LDL cholesterol level below approximately 2 mmol/L, together with excellent aerobic fitness and control of other modifiable risk factors, represented a favorable risk profile in selected aircrew with established CAD. These values should be interpreted within the context of comprehensive cardiovascular risk reduction rather than as an isolated licensing threshold. When statins are insufficient to achieve appropriate lipid control, additional lipid-lowering agents may be clinically indicated. From an aeromedical perspective, such therapies should be evaluated according to treatment indication, pharmacological stability, absence of significant adverse effects, and effectiveness in achieving adequate cardiovascular risk-factor control. The 2019 aviation cardiology consensus noted limited aircrew-specific experience with newer lipid-lowering agents such as PCSK9 inhibitors and therefore recommended individualized assessment.[36]

The FAA likewise places considerable emphasis on cardiovascular risk-factor control during follow-up of pilots with established CAD. Appropriate guideline-directed medical therapy, satisfactory LDL-C control, adequate blood-pressure management, and glycemic control where relevant form part of the overall cardiovascular reassessment.[8] Therefore, lipid-lowering treatment in aircrew should generally be viewed positively when clinically appropriate, effective, and well tolerated. The need for intensive lipid-lowering therapy should not itself be interpreted as evidence of aeromedical unfitness; rather, it reflects appropriate secondary prevention in an individual whose residual anatomical and functional cardiovascular risk must be assessed independently.[2,8,36]

Anti-anginal and Anti-ischemic Therapy

Anti-anginal medication requires a fundamentally different aeromedical interpretation from preventive cardiovascular treatment. Drugs used to suppress ongoing myocardial ischemia or anginal symptoms may indicate that clinically significant coronary disease remains active, even if symptoms are pharmacologically controlled. The EASA

specifically states that applicants with angina pectoris should be assessed as unfit irrespective of whether the symptoms are relieved by medication.[2] Consequently, the ability of nitrates, beta-blockers, calcium-channel blockers, or other anti-anginal agents to prevent chest discomfort should not be interpreted as evidence that the individual is aeromedically safe. The central issue is the underlying ischemic substrate. If an aircrew member requires chronic medication specifically to prevent or suppress anginal symptoms, this suggests that myocardial oxygen supply-demand imbalance may persist. Such a situation requires reassessment of coronary anatomy, ventricular function, and evidence of inducible myocardial ischemia rather than simple consideration of drug tolerability.[2,36]

Long-acting nitrates are particularly important from an aeromedical standpoint. Federal Aviation Administration guidance indicates that the use of a long-acting nitrate in an individual being followed under a coronary heart disease special issuance pathway requires deferral for further FAA review rather than routine recertification by the AME.[8] Thus, chronic nitrate treatment should generally be regarded as an important marker of active or potentially active coronary disease. The medication itself is not the only concern; rather, its requirement suggests that the underlying coronary condition may not meet the expected level of clinical stability for unrestricted flight duties.[2,8] The same conceptual approach applies to other chronic anti-anginal therapies. Where beta-blockers or calcium-channel blockers are prescribed primarily for hypertension or another stable cardiovascular indication, their aeromedical interpretation may differ substantially from their use specifically to suppress anginal symptoms. Therefore, the indication for every cardiovascular medication must be clearly documented.[2,8]

Beta-blockers and Heart-Rate Modulating Therapy

Beta-blockers may be used in patients with CAD for several indications, including post-myocardial infarction management, hypertension, ventricular dysfunction, arrhythmia control, or angina. Their aeromedical implications therefore depend heavily on the reason for treatment. When used as part of secondary prevention or for control of hypertension in an otherwise stable and asymptomatic individual, beta-blocker therapy may be compatible with flight duties provided that the medication is well tolerated and does not produce excessive bradycardia, hypotension, fatigue, dizziness, impaired exercise tolerance, or cognitive impairment.[2,8] In contrast, when a beta-blocker is required primarily to suppress exercise-induced angina or myocardial ischemia, the underlying coronary disease becomes the principal aeromedical concern. Pharmacological suppression of symptoms should not be considered equivalent to elimination of ischemic risk.[2] Beta-blockers may also attenuate the heart-rate response to exercise. This is relevant when interpreting exercise testing in aircrew, because achievement of adequate workload and evaluation of functional capacity remain important components of cardiovascular risk assessment. Exercise capacity should therefore be interpreted together with the individual's medication regimen.[2,36] New initiation or significant dose adjustment of a beta-blocker should also prompt an appropriate period of observation until hemodynamic and operational tolerability are demonstrated, particularly because bradycardia, postural symptoms, and impaired exercise performance may have direct flight-safety implications.[2,8]

Angiotensin-converting Enzyme Inhibitors, Angiotensin Receptor Blockers, and Other Cardioprotective Therapy

Angiotensin-converting enzyme inhibitors and angiotensin receptor blockers may form part of cardiovascular risk reduction in patients with CAD, especially in the presence of hypertension, diabetes mellitus, ventricular dysfunction, or other appropriate clinical indications. These drugs are generally assessed favorably from an aeromedical perspective when blood pressure is adequately controlled and no significant adverse effects are present. Particular attention should be paid to symptomatic hypotension, orthostatic intolerance, dizziness, renal dysfunction, electrolyte disturbances, and any effect that could impair performance during flight operations.[2,8] As with other cardiovascular medications, their use should not be interpreted in isolation. An aircrew member taking an ACE inhibitor or ARB because of well-controlled hypertension may have a very different aeromedical risk profile from an individual receiving the same medication because of significant left ventricular dysfunction following a large myocardial infarction. Thus, the indication for therapy and the underlying cardiovascular substrate remain more important than the pharmacological class itself.[2,8]

Blood-Pressure Control and Multiple Cardiovascular Medications

Hypertension commonly coexists with CAD and constitutes an important modifiable determinant of future cardiovascular events. Effective blood-pressure treatment therefore forms part of secondary prevention in aircrew with established coronary disease. ACE inhibitors, ARBs, selected beta-blockers, calcium-channel blockers, and diuretics may all be clinically appropriate depending on the individual situation. However, treatment should result in stable blood-pressure control without hypotension, orthostatic symptoms, excessive fatigue, or other adverse effects that could impair flight performance.[2,8] Particular attention should be given to aircrew receiving multiple cardiovascular medications because combined therapy may increase the probability of bradycardia, hypotension, electrolyte abnormalities, or reduced exercise tolerance. Polypharmacy should not automatically result in aeromedical disqualification, but the cumulative physiological effects of treatment must be considered. Following initiation of a new cardiovascular medication or significant dosage adjustment, temporary grounding may be appropriate until clinical stability and absence of operationally significant adverse effects have been demonstrated.[2,8]

Pharmacological Therapy Following Myocardial Infarction or Coronary Revascularization

Following myocardial infarction, PCI or CABG, medication is an essential component of secondary prevention. Typical

management may include antiplatelet therapy, intensive lipid-lowering treatment, blood-pressure control and other guideline-directed cardiovascular therapies according to the patient's clinical condition. From an aeromedical perspective, however, successful pharmacological treatment cannot substitute for objective demonstration that the residual cardiovascular risk has become acceptably low. European Union Aviation Safety Agency requires comprehensive reassessment following an ischemic event or coronary revascularization. Appropriate secondary-prevention medication should continue, but medication required specifically to control cardiac symptoms is not considered acceptable as a basis for fitness.[2] For Class 1 assessment, satisfactory coronary anatomy should be demonstrated. European Union Aviation Safety Agency guidance specifies that there should generally be no stenosis exceeding 50% in a major untreated vessel, graft or angioplasty/stent site. Particular attention should be paid to multiple stenoses and repeated revascularization procedures. Untreated disease involving the left main stem or proximal left anterior descending artery carries particular significance. Functional reassessment is also essential. After an appropriate recovery period, exercise testing should demonstrate satisfactory functional capacity without evidence of myocardial ischemia or clinically significant rhythm or conduction disturbance. Ventricular function should remain satisfactory, with a left ventricular ejection fraction of at least approximately 50% under the relevant EASA assessment framework.[2] Following angioplasty or stenting, appropriate stress imaging may be required to demonstrate absence of reversible myocardial ischemia. Additional investigations, including ambulatory ECG monitoring, may be appropriate when arrhythmic risk is suspected.[2]

These anatomical and functional criteria are important specifically because they determine whether pharmacologically treated CAD has reached an acceptably stable state. In other words, aspirin, statins, antihypertensive drugs, or other secondary-prevention therapies may be entirely appropriate, but they cannot compensate aeromedically for residual hemodynamically significant disease, inducible ischemia, or impaired ventricular function.

Residual Coronary Disease and the Role of Medical Therapy

Medical therapy becomes particularly important in aircrew with residual non-obstructive coronary atherosclerosis following investigation or revascularization. Revascularization treats selected stenotic lesions but does not eliminate the systemic atherosclerotic process. Davenport et al[36] emphasized that coronary risk should not be determined solely by the severity of a single stenosis. Overall plaque burden, aggregate stenosis, multivessel involvement, and lesion location are relevant to future cardiovascular event risk. This is important when interpreting pharmacological therapy. Aggressive lipid lowering, antiplatelet therapy where indicated, blood-pressure optimization, smoking cessation, glycemic control, and maintenance of excellent physical fitness may reduce future risk substantially, but they do not eliminate the need for continued surveillance of residual coronary disease.[36] For lesions greater than approximately 50%, functional assessment becomes particularly relevant. Fractional flow reserve or stress imaging may be used when appropriate to determine whether a lesion is hemodynamically significant. In the aviation cardiology consensus described by Davenport et al,[36] an FFR below 0.80 represented evidence of hemodynamic significance. The same consensus proposed assessment of cumulative coronary disease burden through aggregate stenosis. A high cumulative burden, particularly aggregate stenosis exceeding approximately 120%, was considered inconsistent with continued unrestricted professional flying even when individual lesions were not necessarily critically obstructive. These anatomical thresholds are not themselves pharmacological recommendations; rather, they demonstrate the limit beyond which optimal medical therapy alone may not reduce aeromedical risk sufficiently for unrestricted flight duties.

Monitoring Treatment Effectiveness and Adverse Effects

Long-term pharmacological treatment in aircrew requires structured surveillance. The effectiveness of therapy should be assessed through control of cardiovascular risk factors, absence of recurrent angina or acute coronary events, maintenance of satisfactory ventricular function, and preservation of adequate exercise capacity. Laboratory monitoring should be tailored to the medications being used and may include lipid profile, renal function, electrolytes, glucose control, and other clinically relevant parameters. Medication adverse effects have particular importance in aviation. Symptoms such as dizziness, orthostatic intolerance, excessive bradycardia, hypotension, fatigue, muscle weakness, cognitive slowing, or clinically important bleeding may be acceptable inconveniences in ordinary clinical practice but may represent unacceptable operational hazards in professional aircrew. Medication tolerance should therefore be demonstrated not only at rest but also under conditions relevant to operational performance, including exercise and prolonged duty where appropriate.[2,8]

Federal Aviation Administration follow-up of individuals with established coronary disease places emphasis on continued guideline-directed medical therapy, control of LDL-C, blood pressure and glycemic risk factors, absence of new cardiovascular symptoms, stable functional status and absence of clinically significant medication-related bleeding. New chest pain, recurrent myocardial infarction, restenosis requiring intervention, a new coronary procedure, clinically significant bleeding or use of a long-acting nitrate are among the findings that require further FAA review rather than routine aeromedical recertification.[8]

Aeromedical Interpretation of Medical Therapy

The presence of medication should therefore never be considered independently from the coronary disease that prompted its prescription. Preventive therapy such as antiplatelet agents, statins, and appropriate blood-pressure treatment may be compatible with flight duties and should generally be considered an essential component of risk reduction when clinically indicated.[2,8,36]

Conversely, dependence on medication to suppress angina or myocardial ischemia is fundamentally different. EASA specifically considers angina pectoris incompatible with fitness regardless of whether symptoms are relieved pharmacologically.[2]

A useful aeromedical distinction is therefore:

Secondary-prevention medication may support return to flight by reducing future cardiovascular risk, whereas symptom-controlling anti-ischemic medication may indicate persistence of disease that remains incompatible with unrestricted flight operations.[2,8,36]

- The final aeromedical decision should therefore integrate:the indication for each medication;
- clinical stability of coronary disease;
- absence of angina or other ischemic symptoms;
- absence of inducible myocardial ischemia;
- residual coronary anatomy and overall atherosclerotic burden;
- ventricular function;
- functional and exercise capacity;
- LDL-C and other cardiovascular risk-factor control;
- bleeding risk associated with antithrombotic therapy;
- hemodynamic effects of medication;
- absence of operationally significant adverse effects;
- adherence to guideline-directed secondary prevention; and
- estimated risk of recurrent acute coronary events.[2,735]

Overall, pharmacological management of CAD in aircrew should be viewed primarily as a strategy for secondary prevention and long-term cardiovascular risk reduction, rather than simply as treatment of coronary symptoms. Aspirin and other appropriate antiplatelet agents, intensive lipid-lowering therapy, optimal blood-pressure management, and other guideline-directed cardiovascular treatments may be compatible with aviation duties when the individual is clinically stable and medication is well tolerated. In contrast, continuing myocardial ischemia, recurrent anginal symptoms, hemodynamically significant coronary disease, excessive residual coronary burden, impaired ventricular function, recurrent coronary events, clinically important medication adverse effects, or dependence on chronic anti-anginal treatment should prompt grounding, restriction, or further specialist aeromedical evaluation. Thus, aeromedical fitness in pharmacologically treated CAD should ultimately be determined not by the mere presence or absence of cardiovascular medication, but by whether medical therapy has achieved a sufficiently stable, asymptomatic, and low-risk cardiovascular state to meet the safety requirements of aviation operations

Pharmacological Therapy in Cardiac Arrhythmias

Pharmacological therapy for cardiac arrhythmias requires particularly careful aeromedical evaluation because both the underlying rhythm disorder and the treatment itself may influence flight safety. From an aeromedical perspective, the principal concerns include recurrence of a clinically significant arrhythmia, syncope or presyncope, rapid ventricular rates, clinically relevant bradycardia, atrioventricular or intraventricular conduction disturbances, impaired ventricular function, drug-induced proarrhythmia, QT prolongation, and treatment-related neurological, visual, hemodynamic, or systemic adverse effects that could impair operational performance.[2,8,37]

A significant disturbance of cardiac rhythm or conduction should therefore prompt comprehensive cardiological assessment before aeromedical fitness is considered. The assessment should define the type and burden of the arrhythmia, symptom status, recurrence pattern, ventricular rate, presence of pauses or conduction abnormalities, ventricular function, underlying structural or ischemic heart disease, exercise response, and the effectiveness and tolerability of therapy. Depending on the clinical setting, investigations may include a resting 12-lead ECG, ambulatory ECG monitoring, transthoracic echocardiography, exercise testing, and additional imaging or EPSs when clinically indicated. Current aeromedical literature emphasizes that the presence or absence of symptoms and the predicted natural history of the arrhythmia are central elements in determining operational risk.[2,8]

Particular attention is required in AF and atrial flutter because aeromedical risk is determined not only by the arrhythmia itself but also by ventricular rate, symptom burden, recurrence, associated structural heart disease, thromboembolic risk, and the treatment required to maintain adequate rate or rhythm control.[1-3,9] EASA permits consideration of fitness in selected applicants with AF/flutter when cardiological assessment is satisfactory and stroke risk is sufficiently low; when anticoagulation is required, certification is dependent on stable anticoagulation, acceptable hemorrhagic risk, and the applicable medical-certificate class and operational limitation.[2]

Federal Aviation Administration assessment similarly focuses on the functional and clinical consequences of AF rather than on the diagnosis or medication alone. Under the FAA AF AASI pathway, continuing certification requires cardiovascular documentation, a minimum 24-hour cardiac monitor performed within the preceding 90 days, and a cardiology assessment addressing rate or rhythm control, symptoms, treatment, thromboembolic events, CHA_2DS_2-VA score, and embolic-risk mitigation when indicated. Poor rate control, functionally important symptoms, significant pauses, inadequate embolic-risk mitigation, or bleeding requiring medical intervention may require deferral for further FAA review.[8]

Aeromedical fitness should therefore not be determined solely by the presence or absence of antiarrhythmic medication. The indication for treatment, the underlying electrophysiological and structural cardiac substrate, risk of recurrence, probability of sudden or subtle incapacitation, ventricular function, treatment efficacy, and potential adverse effects of therapy should all be incorporated into the decision. A medication that is clinically appropriate may still require aeromedical restriction if it causes bradycardia, hypotension, impaired exercise capacity, visual disturbance,

dizziness, cognitive impairment, or clinically relevant proarrhythmia.[2,37]

Catheter ablation may represent an alternative to chronic antiarrhythmic drug therapy in inappropriately selected aircrew, particularly for recurrent supraventricular arrhythmias or AF. Successful ablation, however, does not automatically restore unrestricted certification. Demonstration of procedural success, freedom from clinically significant recurrent arrhythmia, appropriate post-procedural rhythm monitoring, and satisfactory aeromedical reassessment are required; the observation period and operational restrictions depend on the arrhythmia, certification class, and regulatory authority.[1,2,9] EASA and FAA both provide specific post-ablation assessment pathways rather than treating ablation itself as evidence of immediate fitness.[2,8]

Major Antiarrhythmic and Antithrombotic Agents

Antiarrhythmic drugs should be evaluated according to their electrophysiological effects, indication, underlying cardiac substrate, potential for proarrhythmia, hemodynamic consequences, and extracardiac toxicity rather than being regarded as universally acceptable or unacceptable for aviation duties. Importantly, neither EASA nor FAA provides a universal drug-by-drug list stating that all commonly used Class I or Class III antiarrhythmic agents are compatible with unrestricted flying. Aeromedical assessment must therefore remain individualized.[2,8]

According to the conventional Vaughan–Williams classification, Class I sodium-channel blockers include Class IA agents such as disopyramide and procainamide, Class IB agents such as mexiletine, and Class IC agents such as flecainide and propafenone. Sotalol combines beta-adrenergic blocking activity with Class III potassium-channel-blocking effects, while amiodarone and dronedarone are multichannel agents conventionally classified predominantly within Class III. Modern electrophysiological guidance emphasizes that drug choice must account for structural heart disease, ventricular function, conduction status, renal and hepatic function where relevant, QT interval, drug interactions, and proarrhythmic risk.[37]

Class IA agents such as disopyramide and procainamide warrant particular caution because of their potential to prolong ventricular repolarization and provoke clinically important ventricular arrhythmias in susceptible patients. Class IB agents such as mexiletine are generally used in specific ventricular arrhythmia settings; in such cases, the underlying ventricular arrhythmia and structural cardiac substrate may be of greater aeromedical importance than the medication itself. Class IC agents such as flecainide and propafenone can produce conduction slowing and proarrhythmic effects, particularly in inappropriate cardiac substrates, and therefore require careful assessment of QRS duration, ventricular function, structural heart disease, and arrhythmia control.[37]

Flecainide illustrates why the aeromedical significance of an antiarrhythmic drug depends strongly on its indication. UK Civil Aviation Authority guidance specifically states that flecainide used for AF may be acceptable in selected applicants. However, the same guidance considers flecainide unacceptable for certification when it is being used to treat ventricular arrhythmias, even in a structurally normal heart.[6] Visual or vestibular symptoms should also be specifically questioned because blurred vision and related disturbances may have operational relevance even when conventional ophthalmological function is otherwise preserved.[38]

Sotalol requires consideration of both its beta-blocking effects and its Class III electrophysiological properties. Clinically relevant bradycardia, hypotension, impaired exercise tolerance, QT prolongation, and the risk of torsades de pointes should be excluded before favorable aeromedical consideration. Dronedarone likewise requires individualized assessment, with attention to rhythm control, bradycardia, QT effects, drug interactions, and the clinical condition for which treatment is required. Neither agent should be described as universally aeromedically acceptable solely on the basis of drug class.[2,37]

Amiodarone deserves particularly cautious aeromedical consideration because of its long elimination half-life and broad extracardiac toxicity profile, including potential pulmonary, thyroid, hepatic, neurological, ocular, and bradyarrhythmic effects. A universal aeromedical maintenance-dose threshold—such as 200 mg/day—should therefore not be used as a general criterion for fitness.[37,38] UK CAA guidance explicitly considers amiodarone unacceptable for Class 1 medical certification. For Class 2 certification, treatment usually requires a VCL restricting privileges to daytime flying; unrestricted Class 2 certification may only be considered in selected applicants without relevant night-time glare and following satisfactory ophthalmological review. Consequently, any aeromedical decision concerning amiodarone must remain authority- and license-class-specific rather than being based on dose alone.[38]

The same general principle applies to all antiarrhythmic therapy: successful suppression of an arrhythmia does not automatically establish aeromedical fitness. The possibility of proarrhythmia, excessive bradycardia, conduction disease, QT prolongation, hemodynamic intolerance, interaction with other cardiovascular drugs, and neurological or visual adverse effects should be considered together with the severity and natural history of the underlying arrhythmia.[2,37]

Antithrombotic therapy constitutes a separate but closely related component of arrhythmia management, particularly in AF and atrial flutter. The requirement for oral anticoagulation does not necessarily result in permanent disqualification from aviation duties. Certification may be possible in appropriately selected individuals when the underlying condition is sufficiently stable, anticoagulation is reliably controlled, treatment is well tolerated, and the combined thromboembolic and hemorrhagic risks are acceptable for the level of certification sought.[2,39,40]

For vitamin K antagonist therapy, particularly warfarin, stability of anticoagulation must be demonstrated. Under EASA guidance, anticoagulation is considered stable when at least 5 INR measurements have been documented during the preceding 6 months and at least 4 are within the prescribed therapeutic target range; hemorrhagic risk must also be

acceptable. The applicable operational limitation differs according to medical-certificate class and the underlying indication for anticoagulation. EASA additionally requires ongoing review of INR results during aeromedical follow-up.[2]

The FAA applies a different, indication-specific framework. For non-valvular AF, when the CHA_2DS_2-VA score is 2 or higher, acceptable embolic-risk mitigation strategies for FAA medical certification purposes include warfarin, a NOAC, or left atrial appendage closure. For applicants newly starting warfarin, the FAA requires a minimum 6-week observation period, completion of any additional observation period required for the underlying condition, and 6 INR measurements obtained no more frequently than once weekly. For non-valvular AF, at least 80% of these INR values should be within the 2.0-3.0 range; other therapeutic INR ranges may apply to different indications such as prosthetic valves.[39]

For applicants already established on warfarin therapy, FAA guidance requires documentation of the dosing history, medication tolerance, and adverse effects, together with at least monthly INR results for the preceding 6 months as part of the aeromedical review. Thus, the use of warfarin is not itself an automatic prohibition, but certification depends on the indication for anticoagulation, stability of treatment, bleeding history, and the aeromedical status of the underlying cardiovascular disorder.[7,39]

Direct oral anticoagulants are increasingly relevant to aeromedical assessment. EASA does not identify individual DOACs by name in its general Part-MED anticoagulation provisions; instead, it refers to anticoagulant medication that does not require INR monitoring. Under EASA guidance, a fit assessment may be considered following a stabilization period of 3 months, subject to the relevant medical-assessor review and certificate-class requirements.[2]

UK CAA guidance is more drug-specific and explicitly identifies dabigatran, rivaroxaban, edoxaban, and apixaban as acceptable DOACs for aeromedical consideration. Applicants receiving DOAC therapy should be free of treatment-related adverse effects for 3 months before fitness reassessment and should have satisfactory appropriate blood monitoring. Under the UK CAA framework, certification on anticoagulation may be possible at Class 1 OML level and, in appropriate cases, at unrestricted Class 2 level, provided that the underlying condition is stable and the overall incapacitation and hemorrhagic risks are acceptable.[40]

Federal Aviation Administration guidance also permits NOAC/DOAC therapy in appropriately selected applicants. For applicants newly starting a NOAC/DOAC, a minimum observation period of 2 weeks is required, in addition to any observation period imposed by the underlying cardiovascular condition.[5,6] In the FAA AF pathway, treatment must be tolerated without significant adverse effects or bleeding complications and must form part of an adequate embolic-risk mitigation strategy when the CHA_2DS_2-VA score requires such treatment.[8,39]

Bleeding risk is a critical aeromedical consideration with all forms of anticoagulation. The evaluation should include previous spontaneous or clinically important bleeding, renal and hepatic function as appropriate for the selected anticoagulant, adherence, drug interactions, concomitant antiplatelet therapy when present, and the operational consequences of trauma-associated bleeding. Importantly, the presence of anticoagulation should always be interpreted together with the condition necessitating anticoagulation rather than treated as an isolated medication issue.[2,39,40]

Overall, pharmacological treatment of cardiac arrhythmias in aircrew requires an individualized, risk-based approach. Neither successful rhythm suppression nor stable anticoagulation alone is sufficient to establish aeromedical fitness. The final decision should integrate the underlying arrhythmia, symptom burden, risk of recurrence and sudden or subtle incapacitation, ventricular and structural cardiac function, thromboembolic risk, bleeding risk, treatment efficacy, medication tolerability, and the specific certification class sought. Depending on the regulatory framework and clinical circumstances, multi-crew or other operational limitations may remain necessary even when pharmacological therapy is otherwise compatible with certification.[2,8]

Pharmacological Therapy in Hyperlipidemia

As discussed in detail in the section on pharmacological therapy in CAD, lipid-lowering therapy represents an important component of cardiovascular risk reduction and secondary prevention in aircrew.[2,8,36] Dyslipidemia is common among aviation populations and is usually managed according to standard cardiovascular prevention guidelines.

Major Lipid-Lowering Agents

Statins, including atorvastatin, rosuvastatin, pitavastatin, simvastatin, and fluvastatin, are widely accepted because of their strong cardiovascular risk-reduction benefits and favorable safety profile.[2,8,36] Fibrates, such as fenofibrate and gemfibrozil, may also be acceptable when tolerated and when metabolic stability is maintained.[2,8]

Practical Recommendations

Appropriate pharmacological management allows many cardiovascular conditions to be treated without necessarily resulting in loss of occupational capability. Nevertheless, drug selection in aircrew must always consider both therapeutic efficacy and operational safety. Aircrew members who initiate new cardiovascular therapy or undergo dose adjustments must notify their flight physician or AME, and temporary grounding may be required until treatment tolerability is confirmed. In clinical practice, resources such as the Aviation Medicine Advisory Service database may assist physicians in verifying whether proposed pharmacological therapies are compatible with aviation duties.[41]

RESPIRATORY DISEASE AND FITNESS TO FLY

Although the present review primarily focuses on cardiovascular disease, respiratory fitness remains an important component of aeromedical certification because pulmonary disorders may impair oxygenation, ventilation, exercise tolerance, vigilance, and operational performance. Respiratory conditions of particular aeromedical relevance include chronic airflow limitation, asthma, active inflammatory respiratory

Table 17. Flight Fitness in Respiratory System Diseases

Disease/Condition	Class 1 Fitness
Chronic obstructive pulmonary disease (COPD)	Unfit
Asthma (recurrent attacks)	Unfit
Asthma (stable, appropriate medication use)	Fit with AMS assessment
Active respiratory infections	Temporarily unfit
Sarcoidosis (active)	Unfit
Sarcoidosis (limited, inactive, no medication)	Fit with AMS assessment
Spontaneous pneumothorax (single, healed, after 1 year)	Fit
Spontaneous pneumothorax (single, healed, after 6 weeks)	Fit with OML restriction
Spontaneous pneumothorax (recurrent, after surgery)	Fit with AMS assessment
Spontaneous pneumothorax (recurrent, without surgery)	Unfit
Pneumonectomy (complete lung removal)	Unfit
Chest surgery (minor interventions, fully healed)	Fit with AMS assessment (OML restriction possible)
Sleep apnea (untreated)	Unfit
Sleep apnea (after successful treatment)	Fit
Initial Class 1 Examination (FEV1/FVC <70%)	Pulmonologist assessment required

AME, aviation medical examiner; AMS, Aeromedical Section; COPD, chronic obstructive pulmonary disease; FEV1, forced expiratory volume in 1 second; FVC, forced vital capacity; OML, operational multi-crew limitation; OSL, operational safety pilot limitation.

disease, sarcoidosis, pneumothorax, major thoracic surgery, and obstructive sleep apnea syndrome.[2,6] According to EASA Part-MED, applicants with asthma requiring medication, active inflammatory respiratory disease, active sarcoidosis, pneumothorax, sleep apnea syndrome, major thoracic surgery, pneumonectomy, or chronic obstructive pulmonary disease (COPD) require satisfactory respiratory evaluation before a fit assessment can be considered. Class 1 applicants with these conditions require referral to the medical assessor of the licensing authority, whereas Class 2 applicants are assessed in consultation with the medical assessor.[2] Respiratory assessment is particularly relevant in aerospace cardiology because respiratory and sleep-related disorders frequently interact with cardiovascular and metabolic disease. Their combined effects on oxygenation, exercise capacity, alertness, and cardiovascular risk may materially influence aeromedical fitness.[6,42] The principal aeromedical considerations and fitness-to-fly recommendations for common respiratory system diseases are summarized in Table 17.

Chronic Obstructive Pulmonary Disease

Applicants with clinically significant COPD should generally be assessed as unfit because impaired pulmonary function and gas exchange may compromise physiological reserve. However, applicants with only minor and stable impairment of pulmonary function may be considered fit following satisfactory respiratory evaluation.[2]

Asthma

Asthma may be compatible with certification when the disease is stable, pulmonary function is satisfactory, and the required medication is compatible with flight safety. Recurrent or inadequately controlled asthma requires further assessment. Applicants requiring systemic corticosteroid therapy should be assessed as unfit for active flight duties. For Class 1 applicants, aeromedical assessment should involve the medical assessor of the licensing authority when asthma requires medication. Class 2 applicants may be assessed in consultation with the medical assessor when satisfactory disease control and pulmonary function are demonstrated.[2]

Acute Respiratory Infections

Active inflammatory or infectious respiratory disease should result in temporary unfitness while clinically significant symptoms persist. A fit assessment may be reconsidered after resolution of the condition, particularly when pulmonary function has returned to an acceptable level and no significant sequelae remain.[2,6]

Sarcoidosis

Active sarcoidosis should be assessed as unfit because of the possibility of systemic involvement, particularly cardiac involvement. A fit assessment may be considered when the disease is inactive, requires no continuing medication, and has been shown to be limited to hilar lymphadenopathy. Cardiac or neurological sarcoidosis is incompatible with a favorable aeromedical assessment. The possibility of cardiac involvement is particularly important in aviation medicine because cardiac sarcoidosis may be associated with conduction abnormalities, ventricular arrhythmias, and potential incapacitation. Accordingly, EASA requires satisfactory cardiological evaluation in applicants with established sarcoidosis before certification is reconsidered.[2]

Spontaneous Pneumothorax

Spontaneous pneumothorax is initially incompatible with flight duties because recurrence at altitude may produce significant respiratory compromise. For Class 1 applicants, a fit assessment may be considered 1 year after full recovery from a single spontaneous pneumothorax. At revalidation, an earlier assessment may be considered 6 weeks after full recovery with an OML maintained for at least 1 year after recovery. Recurrent spontaneous pneumothorax is generally incompatible with certification unless successful surgical treatment has been performed and recovery is satisfactory.

For Class 2 applicants, a fit assessment may be considered 6 weeks after full recovery from a single spontaneous pneumothorax when respiratory evaluation is satisfactory. Following surgery for recurrent pneumothorax, certification may also be reconsidered after satisfactory recovery.[2]

Thoracic Surgery and Pulmonary Operations

Applicants undergoing major thoracic surgery should be considered unfit until recovery is complete, they are asymptomatic, and the risk of secondary complications is minimal. Following lesser thoracic procedures, certification may be reconsidered after satisfactory recovery and pulmonary evaluation. Pneumonectomy requires particular consideration because of the permanent reduction in pulmonary reserve. Under EASA Part-MED, Class 1 applicants who have undergone pneumonectomy are assessed as unfit.[2]

Obstructive Sleep Apnea Syndrome

Untreated or inadequately treated obstructive sleep apnea syndrome is incompatible with flight duties because excessive daytime sleepiness and impaired vigilance may compromise operational safety. European Union Aviation Safety Agency specifically requires applicants with unsatisfactorily treated sleep apnea syndrome to be assessed as unfit.[2] Certification may be reconsidered when effective treatment, most commonly continuous positive airway pressure where clinically indicated, has been established and satisfactory treatment adherence and control of symptoms have been demonstrated.[2,42] OSA management should include continued follow-up because treatment effectiveness and compliance are central to maintaining adequate daytime alertness.[42] Beyond its implications for daytime vigilance, OSA is also relevant to cardiovascular risk assessment, particularly in the presence of hypertension; recent data have highlighted the additional burden associated with comorbid insomnia and sleep apnea in hypertensive patients.[43]

Spirometry in the Initial Class 1 Medical Examination

Spirometry is required as part of the initial Class 1 aeromedical examination and should subsequently be repeated when clinically indicated. Applicants with an forced expiratory volume in 1 second (FEV1)/forced vital capacity (FVC) ratio below 70% should undergo further evaluation by a respiratory specialist to determine the presence, severity, and functional significance of airflow limitation. The assessment should consider whether any identified respiratory impairment may adversely affect exercise capacity, oxygenation, or operational performance during flight. For Class 2 applicants, pulmonary function testing should be performed when clinically indicated.[2]

FOLLOW-UP, SURVEILLANCE, AND REVALIDATION

One of the most important principles of aviation medicine is that certification is a process, not a one-time event. Hypertension, diabetes, CAD, valve disease, arrhythmia, device therapy, aneurysm, and congenital heart disease all require periodic revalidation. European Union Aviation Safety Agency repeatedly links certification to satisfactory specialist review, repeat imaging, stable anticoagulation, pacemaker checks, or serial cardiovascular evaluation depending on the diagnosis.

Surveillance should be disease-specific while following a consistent, risk-based framework. Blood-pressure disorders need repeated blood pressure and risk-factor review; diabetes requires HbA1c and complication surveillance; coronary disease requires clinical review plus periodic functional/anatomical reassessment when indicated; heart failure and cardiomyopathy require echocardiography, rhythm surveillance, and biomarker/exercise re-evaluation; pacemakers require annual device checks at minimum; post-valve surgery needs imaging and anticoagulation review; aortic disease needs serial imaging; respiratory disease needs PFT-anchored reassessment when appropriate. Any clinical deterioration, therapy change, or new symptom complex should trigger immediate reconsideration of fitness.

CONCLUSION

Aeromedical cardiovascular assessment is a high-consequence application of clinical cardiology. The essential principle is not whether a disease can be treated, but whether the residual risk of sudden or subtle incapacitation is compatible with the license privileges being exercised. Current aeromedical standards under ICAO, EASA, FAA, and DGCA converge on this point even when operational details differ.

Aeromedical cardiovascular assessment should follow a structured hierarchy based on diagnosis, disease severity, ventricular function, arrhythmic and thromboembolic risk, treatment compatibility, and the required intensity of surveillance. Under this framework, controlled hypertension, stable non-hypoglycemic diabetes therapy, successfully treated coronary disease, selected low-risk arrhythmias, minor valvular abnormalities, small stable aneurysms, and simple repaired congenital lesions may remain certifiable in some applicants. Conversely, unstable metabolic disease, significant residual ischemia, reduced EF, malignant arrhythmia, ICD therapy, severe valvular or aortic pathology, complex congenital disease, active pulmonary sarcoid, recurrent pneumothorax, and untreated sleep apnea generally preclude safe certification.

This review integrates contemporary cardiovascular guidance with the aeromedical standards applied by ICAO, EASA, FAA, and Turkish DGCA. It is intended to serve as a practical clinical reference rather than a formal ESC guideline. Certification decisions should remain individualized and should account for residual incapacitation risk, treatment-related effects, license class, and the operational demands of the specific aviation role.

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