

Guidelines for the Assessment of Cardiovascular Fitness in Licensed Aviation Personnel 2012

Transport Canada Civil Aviation Medicine

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Foreword to the 4th Edition

The presence or development of cardiovascular disease in licenced aviation personnel, with the risk of potential clinical manifestations, continues to be a major concern to aviation medical practitioners. The evaluation and management of aeromedical risk continues to be a balancing act between practicality, risk tolerance and the advances of diagnostic medicine.

The advances in medical and surgical treatment of cardiovascular disease have allowed many pilots and air traffic controllers to return, after successful treatment, to licenced duties without jeopardizing aviation safety.

This fourth edition of the Canadian cardiovascular guidelines is intended to assist in the medical assessment of cardiovascular fitness of licensed aviation personnel. It reflects a consensus reached as a result of discussions and recommendations made during an aviation cardiology workshop held in Ottawa, on February 1st, 2010, arranged by Civil Aviation Medicine Branch, Transport Canada.

It must be emphasized that these guidelines are to be used only as a guide to practice and evaluation of licensed aviation personnel. No publication can hope to keep up with all the advances in this rapidly evolving field and each licence holder's individual situation must be investigated and evaluated in light of the most up-to-date clinical guidance. These guidelines should not be confused with the medical regulations set out in the *Canadian Aviation Regulations* part 424 published by Transport Canada.

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Comments are always welcome, and any specific questions should be directed to Civil Aviation Medicine Branch, Transport Canada Ottawa or to any Regional Aviation Medical Officer. Contact information is available from the Branch website at

<http://www.tc.gc.ca/eng/civilaviation/opssvs/cam-menu.htm>

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Introduction

No disease condition is as rich with data to determine risk of medical fitness to fly as cardiovascular disease. Eight years have elapsed since the last review of the Guidelines for the Assessment of Cardiovascular Fitness in Canadian Licenced Aviation Personnel. Significant progress is being made in the identification of subsets of patients who are at high risk of a cardiovascular event based on more sophisticated technologies and expanding databases of well defined cases. Genetic epidemiology, still in its early stages contributes even more precision to an assessment of risk in individuals. The challenge remains to identify in a cost effective manner those at an unacceptably high risk of incapacitation among the majority of otherwise medically fit pilots and air traffic controllers. This challenge is compounded by the continuous aging of the pilot population as well as the entry of older Canadians who wish to take up flying for the first time. The likelihood of a cardiovascular event increases with age, therefore it is reasonable to consider the application of a different level of scrutiny to older individuals. Nevertheless there are pilots in their 70s and 80s who have been assessed medically fit to fly.

Cardiovascular experts who recently (February 1, 2010) reviewed the Guidelines published in 2002 felt that only a few updates and refinements were required and these have been incorporated. The one day Workshop included Regional Aviation Medical Officers, cardiovascular and aviation medicine consultants including from the Armed Forces and staff from the Civil Aviation Medicine Branch and Air Safety, Transport Canada.

The Guidelines in effect seem to be serving us well as evidenced by no fatal aviation accident in Canada over several decades, with an established cardiovascular cause.

Aviation Medical Standards are laid down in Annex 1 to the Convention on International Civil Aviation by the International Civil Aviation Organization (ICAO) to which Canada is a contracting state. The standards identify broad medical conditions that on the basis of expected risk of incapacitation disqualify a pilot from flying an aircraft. In countries where the standards are applied strictly, affected pilots may never return to flying. Such a strict policy may be unfair to those aviation personnel in whom the risk of sudden incapacitation becomes acceptably low as a result of risk factor modification or rehabilitation including some therapeutic interventions. Canada on the other hand has used the concept of flexibility and accredited medical opinion to determine medical fitness where circumstances do not meet the standards as written.

Our ability to assess risk in an individual continues to improve as experience with groups bearing similar risk profiles increases. Progress with the assurance of a safe flying environment e.g. through widespread incapacitation training, has also allowed more tolerance of certain medical conditions. The risk of a fatal accident occurring as a result of medical incapacitation is dependent on a number of factors. These include the amount of time spent flying, the type of flying (eg aerobatics), the risk of an incapacitation occurring at a critical phase of flight and the risk that such incapacitation is not mitigated by the presence of other qualified aircrew. All of these factors must be taken into consideration in addition to the known medical risk of a given medical condition.

Experience with cardiac disease in the general population along with experience with simulators allows an estimation of risk in a fashion similar to that used in other risk evaluation settings by structural engineers. It can be rationalized that an annual risk of incapacitation up to 2% (which includes *a 1% risk due to a fatal occurrence as well as a 1% risk due to an incapacitating but nonfatal occurrence*) due to a medical condition in an unrestricted pilot can be tolerated, as that would translate into an acceptably low risk of a resulting fatal accident. Where there is insufficient precision in estimating risk for the medical condition of a given applicant, then we continue to determine medical fitness applying a cautious approach.

Chapter 1: Ischemic Heart Disease

Chest Pain

Chest pain, regardless whether typical or atypical for ischemic heart disease, precludes medical certification insofar as it indicates an elevated probability of significant coronary artery disease and an increased risk of an incapacitating cardiac event.

An applicant may be considered medically fit if diagnostic testing indicates that the chest pain is not due to myocardial ischemia. The initial assessment including a review of the symptom history must be made without the effect of anti-ischemic medications that could possibly mask adverse findings. If coronary arteriography reveals normal coronary arteries, coronary vasospasm should be clinically excluded. The presence of continuing symptoms of chest pain in the

absence of ischemia is not disqualifying per se; however, such symptoms must not be incapacitating in any way.

Acute Coronary Syndrome

Acute coronary syndromes include unstable angina, non-ST elevation (NSTEMI) as well as ST elevation (STEMI) myocardial infarctions. An acute coronary syndrome is initially incompatible with medical certification. However, disqualification is not necessarily permanent, and medical certification may be considered 6 months after the event (a decision at 6 months must be based on requisite assessments completed no sooner than 5 months after discharge from hospital) provided the following criteria are met:

- The result of an exercise test to a minimum of 8.5 METS using the Bruce protocol or equivalent places the individual at low (<2%) risk of a significant cardiovascular event over the following 12 months. If a perfusion exercise test is used, there should be no significant reversible defect and no large fixed deficit as explained in the next point.
- The left ventricular ejection fraction as a measure of left ventricular function using echocardiography or gated radionuclide scintigraphy, is better than 50% at rest and does not show a decrease of more than 5% with satisfactory exertion (i.e. 85% predicted maximum heart rate or > 8 METS). A threshold ejection fraction of 45% applies with the use of SPECT (single photon emission computerized tomography) scanning.
- With a satisfactory ejection fraction as described above, Holter monitoring is not required. For an ejection fraction between 40%

and 50%, restricted medical certification may be considered after review of a 24 hour Holter monitor. This should reveal no more than 3 ventricular ectopic beats per hour in the absence of antiarrhythmic medication, with no more than 3 consecutive beats and a cycle length that is not less than 500 msec.

- Major modifiable risk factors (see below) for recurrence of infarction are controlled, and the applicant is a non-smoker.

Medications need not be stopped for these tests.

Extensive and severe coronary disease, particularly if the left main coronary artery is involved with disease, even if revascularized will likely be viewed unfavourably.

A follow-up assessment a year after the infarction and then annually should include a thorough history, physical examination, rest and exercise electrocardiography and a review of modifiable risk factors. If there is no clinical deterioration after 2 years, the treadmill exercise test can be done every 2 years until a need for yearly testing is indicated.

These criteria apply regardless of whether the applicant was treated for acute thrombosis with a thrombolytic drug, percutaneous coronary intervention (PCI) or bypass surgery, or the infarction occurred in the presence of only mild to moderate atheromatous disease as demonstrated by arteriography.

Following Revascularization

An applicant who has been treated for coronary artery disease by revascularization including bypass surgery, angioplasty with or without stenting, directional atherectomy etc., can be considered for medical certification after an interval of 6 months, with testing completed not earlier than 5 months after the revascularization. The criteria for consideration are the same as following an ACS (above).

The older individual and/or those with increased complexity of coronary disease, e.g., multi-vessel involvement will likely need on-going yearly assessments.

Risk Factors for Ischemic Heart Disease

The following are major modifiable risk factors for ischemic heart disease. While many of them may have impressively large relative risks, their absolute risk, particularly for sudden incapacitation, is low. Concern about these risk factors is greater in applicants with known ischemic heart disease where the absolute risk is greater. The presence of major modifiable risk factors should be a concern in any applicant and preventive measures are strongly advised.

Smoking

Prohibition of smoking in the cockpit is now the norm for all flights of any duration. Anyone with known ischemic heart disease who continues to smoke is considered medically unfit.

Increased serum cholesterol levels

All applicants are encouraged to be aware of their serum lipid levels and to maintain normal levels. Target levels depend on the level of risk as outlined in the 2009 Canadian Cardiovascular Society Guidelines.

Table 1. All currently approved medications for lipid lowering are compatible with flying.

Table 1 - Target Lipid Levels

<i>Risk level</i>	Primary Target: LDL-C	Alternate Target
High CAD, PVD, Atherosclerosis Most patients with diabetes FRS $\geq 20\%$ RRS $\geq 20\%$	<2 mmol/L or $\geq 50\% \downarrow$ LDL-C	apoB <0.80 g/L
Moderate FRS 10% - 19% LDL-C >3.5 mmol/L TC/HDL-C >5.0 Hs-CRP >2 mg/L Men >50 years Women > 60 years Family history and Hs-CRP modulates Risk (RRS)	<2 mmol/L or $\geq 50\% \downarrow$ LDL-C	apoB <0.80 g/L
Low FRS <10%	$\geq 50\% \downarrow$ LDL-C	

High Blood Pressure

The recommended approach to the diagnosis of hypertension is in keeping with that of the Canadian Hypertension Education Program (CHEP). In licence holders with accurately measured blood pressure, if the systolic blood pressure (SBP) is 140 mmHg or greater and/or the diastolic blood pressure (DBP) is 90 mmHg or greater, a specific visit should be scheduled for the assessment of hypertension. The process to follow in order to establish the diagnosis of hypertension as well as pharmacologic and nonpharmacologic treatment strategies are outlined in the CHEP recommendations (<http://hypertension.ca/chep/recommendations-2010/>), the details of which are beyond the scope of these Guidelines.

For the assessment of medical fitness in pilot applicants, it is important that hypertension be controlled. If pressures remain at or above 160 mmHg systolic or 100 mmHg diastolic, it is strongly recommended that drug treatment be initiated. Treatment should also be considered when the diastolic pressure is between 90 and 100 mmHg in the presence of macrovascular target organ damage or other independent cardiovascular risk factors. The goal of systolic blood pressure treatment is <140 mmHg and <90 mmHg for diastolic blood pressure. For anyone with diabetes as well as non-diabetic chronic kidney disease, the target blood pressure is <130/80 mmHg.

Medical certification can be granted when treatment has been successful in reducing the blood pressure below 160 mmHg systolic and below 100 mmHg diastolic, however optimal blood pressure is less than 120/80 mmHg in most individuals including the elderly and to less than 130/80 mmHg in those with diabetes or renal dysfunction.

On any visit, a blood pressure level of 180 mmHg or more systolic or 110 mmHg or more diastolic is incompatible with medical certification.

Therapeutic Considerations

Initial therapy should be monotherapy with a thiazide diuretic; a beta-blocker (in those younger than 60 years of age); an ACE inhibitor (in nonblack patients); a long-acting CCB or an ARB. If there are adverse effects, another drug from this group should be substituted.

Hypokalemia should be avoided in patients treated with thiazide diuretic monotherapy.

Additional antihypertensive drugs should be used if target blood pressure levels are not achieved with standard dose monotherapy. Add-on drugs should be chosen from first line choices. Beta-blockers are included for those under 60 years of age. In licence holders, the major challenges with treatment are to minimize postural hypotension, the risks of arrhythmias and adverse CNS effects.

Preferred drugs in an aviation environment include:

1. β -blockers: hydrophilic drugs are preferred (e.g. atenolol, nadolol, timolol).
2. Calcium channel antagonists: long-acting dihydropyridines are preferred (e.g. amlodipine, felodipine, nifedipine XL).
3. ACE-inhibitors: long-acting ACE-inhibitors are preferred such as ramipril, cilazapril, fosinopril, lisinopril, quinapril, etc.
4. Low dose diuretics: hydrochlorothiazide (< 25 mg/day) or potassium/ magnesium sparing diuretics such as amiloride and spironolactone should be used

Acceptable drugs include:

1. Angiotensin receptor blockers (ARBs) which are similar to ACE inhibitors in their hemodynamic action. They can be used singly or in combination, with the exception mentioned below. As with ACE inhibitors, ARBs are acceptable in pilots who have been on one of these medications for a month or more without any adverse effects.

Drugs that are not permitted include:

1. Sympatholytics: guanethidine, most alpha blockers
2. High dose kaliuretic diuretics (> 25 mg hydrochlorothiazide or equivalent).
3. Clonidine and methyldopa (because of a risk of rebound hypertension if these medications are inadvertently not taken).
4. The combination of a nondihydropyridine calcium channel blocker with a beta-blocker.
5. The combination of an ACE with an ARB in those with coronary disease.

Combination treatment, eg a low dose diuretic with an ACE inhibitor may be allowed particularly as small doses of medications in combination may lead to fewer adverse effects than larger doses of single agents.

Multiple Risk Factors

Coronary atherosclerosis is a multifactorial disease, the risk of early onset increasing with the number of risk factors present. Therefore the

assessment of risk must weigh appropriately the contribution of the various factors present. The cumulative risk conferred by the presence of more than one risk factor, even at levels only moderately above normal, can exceed that conferred by the presence of one major risk factor alone. The presence of only moderately elevated levels of risk when any risk factor is assessed alone should not lead to a false sense of security.

If the 10 year risk score is 20% or greater (9 risk points for men and 15 risk points for women, Table 2) or if diabetes or left ventricular hypertrophy are present, then a cardiovascular assessment including an exercise treadmill test should be carried out. Additional tests will depend on the risk factor profile. If abnormalities are found, resulting in an average annual mortality risk of 1% or more, assuming an additional 1% risk of an incapacitating nonfatal event, then a licence holder is considered medically unfit for an unrestricted licence. Even if the response to exercise testing is normal, appropriate therapy to modify risk factors should be initiated.

Global Risk

Using the Framingham risk scoring system, total risk can be assessed on the basis of risk points for age, total and HDL cholesterol, systolic blood pressure and smoking status in the absence of existing coronary heart disease or diabetes. Table 2. In order to use the scoring system, cholesterol determinations are necessary. While a global risk assessment may not be required of all pilots, obesity particularly in the midline, an abnormal resting ECG or other factors raising concern

about possible coronary disease should result in a global assessment of risk.

The presence of either existing coronary heart disease or diabetes places the individual applicant in a potentially high risk category, thus warranting further investigation.

Table 2 - 10-Year Absolute Risk of CVD Event

RISK FACTOR	MEN	WOMEN	SCORE	
Age (years)				
<34	-1	-9	}	-
35-39	0	-4		
40-44	1	0		
45-49	2	3		
50-54	3	6		
55-59	4	7		
60-64	5	8		
65-69	6	8		
70-74	7	8		
Total cholesterol (mmol/L)				
<4.14	-3	-2	}	-
4.15-5.17	0	0		
5.18-6.21	1	1		
6.22-7.24	2	2		
>7.25	3	3		
HDL cholesterol (mmol/L)				
<0.90	2	5	}	-
0.91-1.16	1	2		
1.17-1.29	0	1		
1.30-1.55	0	0		
>1.56	-2	-3		
Systolic blood pressure (mmHg)				

<120	0	-3	}	—
120-129	0	0		
130-139	1	1		
140-159	2	2		
>1.60	3	3		
Smoker				
No	0	0	}	—
Yes	2	2		

Total Risk Points ____ (in individuals who have not had a prior CVD event)																		
Risk Points	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Chd	Men	3	4	5	7	8	10	13	16	20	25	31	37	45	53			
Risk	Women	2	3	3	4	4	5	6	7	8	10	11	13	15	18	20	24	>27

Chapter 2: Structural Heart Disease

Valvular Heart Disease

The significance of valvular heart disease depends primarily on the hemodynamic consequences, functional status and in some cases, the etiology of the valve disease. In the majority of cases, surgical correction will not reduce the risk of sudden incapacitation to acceptable levels; in some cases it may even increase the risk.

Aortic Stenosis

Moderate or severe stenosis is unacceptable for unrestricted flying. Applicants with mild stenosis of the aortic valve can be considered for licensure if the following conditions are met:

- The transvalvular flow velocity across the valve is not more than 3 m/sec.
 - The cross-sectional valve area is not less than 1.2 cm², taking into account the individual's body size.
 - Left ventricular systolic function is normal
 - There are no related symptoms.
 - Holter monitoring reveals no significant dysrhythmia such as uncontrolled atrial fibrillation or sustained ventricular tachycardia.
 - A satisfactory treadmill exercise test, to a minimum of 8.5 METS using the Bruce protocol indicates no ischemia, hypotensive blood pressure response, significant arrhythmia or disabling symptoms.
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Aortic Regurgitation

Pure isolated regurgitation is uncommon; therefore, assessment of applicants with aortic regurgitation will likely include consideration of any associated disorders such as an abnormality of the valve leaflets or aortic root. Individuals with no more than mild to moderate, asymptomatic aortic regurgitation can be considered if the following criteria are met:

- The pulse pressure is less than 70 mmHg and the diastolic pressure is greater than 65 mmHg.
- Left ventricular systolic function is normal
- The end-diastolic internal diameter of the left ventricle is less than 57 mm and the end-systolic internal diameter is less than

40 mm, taking into account the individual's body size, as measured by two-dimensional echocardiography.

- A satisfactory treadmill exercise test, to a minimum of 8.5 METS indicates no ischemia, significant arrhythmia or disabling symptoms.
-

Follow-up for Aortic Valve Disease

Follow-up should include a yearly assessment with comprehensive 2-D and Doppler echocardiography to monitor for disease progression.

Mitral Stenosis

In view of its progressive nature and propensity for atrial fibrillation and thromboembolic complications, most applicants with mitral stenosis are medically unfit. Only those with very mild mitral stenosis including a cross sectional mitral valve area $> 2.0 \text{ cm}^2$ and stable normal sinus rhythm may be considered.

Mitral Regurgitation

The etiology of mitral regurgitation can alter the prognosis; therefore, an assessment of this condition should include information about the likely underlying cause, in addition to an estimate of the severity of the lesion. Asymptomatic mitral regurgitation of less than moderate severity may be acceptable in applicants if the following conditions are met:

- Mitral stenosis is absent.
 - The diameter of the left atrium is less than 4.5 cm.
 - Left ventricular systolic function is normal
 - Atrial dysrhythmia such as atrial fibrillation/flutter or a sustained supraventricular tachycardia are absent, as determined by Holter monitoring.
 - There is no history of embolism.
 - The probability of significant coronary artery disease is low based on the results of a submaximal treadmill exercise test.
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Mitral Valve Prolapse

Mitral valve prolapse has a wide spectrum of severity. Most cases are mild and detectable either by the presence of a midsystolic click and/or a soft murmur. The diagnosis is established by echocardiography. Medical certification may be considered if the following conditions are met:

- There is no history of embolism or transient cerebral ischemia.
- There is no relevant family history of sudden death.
- Mitral regurgitation, if present, is less than moderate in severity.
- The left ventricular end-diastolic size does not exceed 60 mm.
- Left ventricular systolic function is normal.

If the left atrial size is increased or if there is redundancy of the mitral valve leaflets, then a treadmill exercise test and 24 hour Holter-monitoring will be required as these findings can be markers of increased risk.

Follow-up for Mitral Valve Disease

Annual follow-up for mitral valve stenosis should include a thorough history and physical examination, comprehensive 2D and doppler echocardiogram and 24 hour Holter monitoring. For mitral regurgitation, annual follow-up should include a thorough history, physical examination and comprehensive 2D and doppler echocardiogram. The follow-up for mitral valve prolapse will be determined on a case-by-case basis depending on the degree of prolapse and any associated findings.

Surgical repair or replacement of valves

The prosthetic or repaired valve must be functioning satisfactorily with no significant regurgitation (less than moderate). Left ventricular function (EF) must be at least 50% and individuals should have an exercise tolerance of at least 8.5 METS with no inducible ischemia. There must be no incapacitating arrhythmias. Those taking anticoagulants must demonstrate well-managed therapeutic INRs. Other factors such as the condition of other non-replaced valves, vascular changes i.e. aortic dilatation, history of endocarditis, thromboembolism etc will require evaluation on a case by case basis.

In view of the risk of thromboembolism, valve failure endocarditis and bleeding secondary to anticoagulation, prosthetic valvular replacement will disqualify most applicants. Where the cumulative risk of incapacitation due to these factors can be shown to be less than 2% per year and thus comparable to the acceptable level of risk with other conditions, an applicant may be considered medically fit.

Special procedures including the Ross procedure and homograft valve replacements will be considered on a case by case basis. The former requires a waiting period of at least 12 months to rule out pulmonary stenosis as a complication.

Following surgical reconstruction (valvuloplasty) of the mitral valve, a licence holder may be considered medically fit to fly if an assessment after 3 months including an echocardiogram indicates no clinically significant residual hemodynamic abnormalities, the presence of sinus rhythm and no incapacitating arrhythmias.

Congenital Heart Disease

Atrial septal defect

Applicants with a patent foramen ovale or a small sinus venosus or secundum defect (pulmonary/ systemic flow ratio less than 2:1 and normal right heart pressures) as determined by doppler echocardiography or cardiac catheterization and without recurrent atrial arrhythmias need not be restricted from flying. Applicants with partial atrioventricular canal defects (primum type atrial septal defects) cannot have more than mild mitral regurgitation, and they must meet the same requirements for flow ratios and atrial arrhythmias.

Those who have undergone a transcatheter correction or a surgical correction of a larger defect may be medically certified if 3 months after the procedure they meet the same requirements, provided there has not been a significant event associated with their defect. A post-

operative follow up echocardiographic evaluation is required to determine the extent of any residual leakage and shunting.

Coarctation of the Aorta

Licence holders with surgically corrected coarctation of the aorta should be considered individually. The age at the time of the surgical correction will be a major determinant in the decision about medical certification of a licence holder since the risk of sudden death and incapacitation due to cerebrovascular accidents is markedly increased in people who undergo surgery after the age of 12 years. In all cases the blood pressure at rest and in response to exercise must be normal.

Pulmonary Stenosis

The major determinant of risk in applicants with this condition is the severity of the stenosis. Those with mild pulmonary stenosis and normal cardiac output will be considered for licensure provided the following criteria are met:

- The peak systolic pressure gradient across the pulmonary valve is less than 50 mmHg, and the peak systolic right ventricular pressure is less than 75 mmHg, as determined by echocardiography or cardiac catheterization.
- Symptoms are absent.
- The result of a submaximal treadmill exercise test is normal.

Applicants with pulmonic stenosis corrected by surgery or balloon valvuloplasty will be considered fit if there is no dysrhythmia and if the hemodynamic parameters are not worse than those described above.

Ventricular Septal Defect

An applicant's eligibility for medical certification will depend on the size of the ventricular septal defect as indicated by the hemodynamic consequences. In the absence of surgical correction an applicant may be considered for licensure if the following conditions are met:

- The heart size is normal.
- The pulmonary/systemic flow ratio is less than 2:1, as determined by echocardiography or cardiac catheterization.
- The pressures in the right heart are normal.

An applicant with a surgically corrected ventricular septal defect may be considered for medical certification if the same conditions are met as for no surgical intervention, and in addition:

- No dysrhythmias or high-grade conduction disturbances are detected by Holter monitoring.
 - The response to a submaximal treadmill exercise test is normal.
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Tetralogy of Fallot

The unoperated condition with cyanosis is incompatible with medical certification. Individuals who undergo repair of Tetralogy of Fallot may

be considered for medical certification if the following conditions are met:

- Normal arterial oxygen saturation.
 - Normal heart size.
 - Right ventricular systolic pressure less than 75 mmHg and peak RV/PA gradient less than 50 mmHg.
 - Residual interventricular shunt not more than 1.5:1.
 - No dysrhythmias or high-grade conduction disturbances by Holter monitoring.
 - Normal performance on a treadmill exercise test.
-

Transposition of Great Arteries

The unoperated condition is incompatible with medical certification with the sole exception of congenitally corrected transposition without any other associated cardiac abnormalities.

Applicants with atrial switch corrective procedures for transposition of the great arteries are unlikely to be eligible for medical certification because of the increasing propensity to atrial arrhythmias with passing years, even with technically excellent surgery. Applicants who have had arterial switch operations will need to be considered separately when this cohort begins to reach adulthood.

Inflammatory Heart Disease

Active pericarditis and/or myocarditis are medically disqualifying. Medical certification may be considered after satisfactory recovery with no adverse sequelae.

Cardiomyopathy

Obstructive hypertrophic cardiomyopathy poses a significant risk for sudden incapacitation and generally renders an applicant medically unfit to fly even if there has been surgical treatment. Applicants with minor asymmetric hypertrophy will be considered individually based on the degree of outflow obstruction and the nature of any arrhythmias.

Nonhypertrophic cardiomyopathies dilated or congestive, in their active phase disqualify an applicant from flying. Symptomatic heart failure even with normal quantification of left ventricular function is incompatible with safe piloting. Cardiac catheterization is usually required to rule out ischemia as the etiology of the cardiomyopathy. Recertification may be considered after recovery if the following conditions are met:

- Symptoms are absent.
- A satisfactory exercise tolerance test to a minimum of 8.5 METS, using the Bruce protocol indicates no ischemia, significant arrhythmia or disabling symptoms.
- Left ventricular function as determined by echocardiography is satisfactory, i.e. EF > 50%. An ejection fraction between 40% and 50% may be acceptable for restricted flying provided 24 hour Holter monitoring reveals no more than 3 ventricular

ectopic beats per hour in the absence of antiarrhythmic medication, with no more than 3 consecutive beats and a cycle length of not less than 500 msec. Nonsustained ventricular tachycardia in someone with an ischemic cardiomyopathy is not acceptable.

- The risk of thromboembolism and (if applicable) the risk of hemorrhage secondary to anticoagulation is acceptable.

Cardiac Transplantation

Due to the cumulative high rate of morbidity including the insidious progression of coronary disease and an increasing mortality rate over time, applicants are unlikely to be medically fit to fly unrestricted following cardiac transplantation. Experienced pilots with a low grade of rejection, no evidence of coronary ischemia and satisfactory control of modifiable risk factors may be considered medically fit for restricted flying.

Chapter 3: Arrhythmias and Devices

All applicants with dysrhythmias should be evaluated with two questions in mind: what is the nature of the disability produced by a given arrhythmia i.e., how incapacitated is the applicant when the dysrhythmia occurs? and what is the underlying condition of the heart? i.e., is structural heart disease present? Both questions must be answered before a decision can be made about medical fitness to fly.

Supraventricular Dysrhythmias

Supraventricular tachydysrhythmias may accompany self-limited illnesses e.g., pneumonia or treatable conditions e.g. hyperthyroidism. In such cases, the need to restrict flying will be only temporary.

Applicants in whom treatment with an antiarrhythmic agent is successful need not be restricted from flying. Given the high rate of success with ablation therapy, individuals may be considered medically fit one month after the procedure. Applicants who undergo AV nodal ablation of the slow pathway are more likely to be reconsidered favourably because of the lower risk of development of heart block.

Sinus Node Dysfunction

Isolated sinus node dysfunction including sinus bradycardia may occur in healthy people, particularly those involved in vigorous exercise programs. Such a finding (a consequence of high vagal tone) need not necessarily be considered an abnormality. Provided the dysfunction does not interfere with mental function, the licence holder need not be restricted from flying. Where there is concern e.g. extreme bradycardia, a thorough symptom history should be followed by Holter monitoring and a treadmill exercise test. Even in a healthy applicant, no R-R interval should exceed 4 sec during sleep or 3 sec while awake.

Atrial Fibrillation/Flutter

There are 3 major concerns in the assessment of the risk of incapacitation in an individual with atrial fibrillation or flutter. The first is the hemodynamic effect of the arrhythmia itself. The second is the risk of embolism and the third is the risk of bleeding as a consequence of anticoagulation. Since risk is additive, the aggregate risk must remain within acceptable limits. Therefore it is possible that selected aircrew may be considered medically fit depending on their condition and the effect of treatment.

Ablation therapy is increasingly used for atrial flutter and is highly successful (98%). Such individuals can be considered medically fit within a month of the procedure. Ablation therapy is less successful (80% with up to 2 procedures) in those with atrial fibrillation. An assessment should take place at 3 and 6 months following ablation for atrial fibrillation.

The risk of thromboembolism can be assessed using the CHADS₂ scoring system, recognizing that risk increases with increasing age. The lowest risk is seen in those below 75 years of age who have intermittent or chronic, lone atrial fibrillation, i.e. no identifiable cause of the arrhythmia and no underlying structural heart disease. Annual follow-up in such cases should include 24 hr Holter monitoring. Individuals with atrial fibrillation who have 2 or more of the 5 major risk factors, including age >75 years, structural heart disease, diabetes, high blood pressure and previous thromboembolism are considered to be above the threshold level of risk (5%) even when fully anticoagulated. Anticoagulation carries a bleeding risk that is increased with factors such as previous bleeding, hypertension and age > 75 years and can be estimated with the HEMORR₂HAGES score.

Thus, older license holders with structural heart disease generally have a cumulative risk of embolism and bleeding secondary to anticoagulation that exceeds the limit for medical fitness. The introduction of newer anticoagulants with the same or better efficacy than coumadin but with less bleeding risk may improve the cumulative risk for some individuals.

Pre-Excitation Syndromes

Not all cases of Wolff-Parkinson-White (the most common type of pre-excitation) are associated with incapacitating dysrhythmias. The risk of incapacitating symptoms in people who have never had tachycardia is low but is not known with any precision. Applicants with only an electrocardiographic indication, whether chronic or intermittent, and no history of palpitations may be fit to fly if their response to a treadmill exercise test is normal in all respects particularly if evidence of preexcitation is lost at accelerated heart rates. Such individuals are unlikely to conduct at a dangerously high rate if in atrial fibrillation. Electrophysiologic studies are not required in such cases.

Medical certification in a restricted capacity may be considered 3 months after a symptomatic episode of tachycardia has been controlled with medication. Applicants in whom accessory pathway connections have been ablated surgically or by catheter techniques are considered medically fit if at 3 months they are asymptomatic and their electrocardiogram shows no evidence of pre-excitation. In some cases a treadmill stress test or repeat electrophysiologic studies may be required 3 months after surgery to confirm a successful intervention.

Ventricular Dysrhythmias

The main concern with ventricular dysrhythmias is the underlying condition of the myocardium. A careful assessment should be done to determine the presence of structural heart disease. If the myocardium is normal, ventricular ectopy should be judged on the basis of the disability produced and, to a lesser extent, on the presence or absence of complex forms. Although the complexity of premature ventricular beats is poorly correlated with risk in the presence of normal myocardial tissue, the appearance of multiform or repetitive forms of ventricular ectopy i.e., couplets, runs, should indicate the need for a thorough cardiac examination since these and other high grade forms of ectopy are more commonly seen in association with structural heart disease. If the ventricular ectopic beats have a LBBB pattern particularly with a vertical axis, right ventricular dysplasia should be ruled out by either invasive (ventriculography) or non-invasive (echo, MRI or radionuclide scintigraphy) tests.

In the presence of one or more PVCs on a resting 12-lead electrocardiogram, consideration should be given to an echocardiographic study and/or 24 hour Holter monitoring.

Exercise-induced ventricular tachycardia can occur in healthy people. These events are usually selfterminating. Medical certification need not be restricted in such cases unless there are recurrent episodes. Individuals with sustained tachycardias are unfit.

Electrocardiographic findings suggesting Brugada's syndrome, in the absence of symptoms and a family history of arrhythmias or sudden death do not require any restriction.

Conduction Disorders

First-and-second-degree (type 1) atrioventricular conduction delay can be seen during rest (particularly sleep) in healthy people with a structurally normal heart who engage in vigorous exercise. High grade atrioventricular block should be investigated to rule out heart disease and to determine the risk of progression to complete heart block. Likewise first and second-degree block with structural heart disease should be investigated to determine the risk of progression to complete heart block.

Bundle Branch Block

Left bundle branch block and right bundle branch block of recent onset, indicate the need for a cardiovascular examination to rule out heart disease, especially ischemic heart disease. Isolated right bundle branch block and left hemiblocks that are longstanding are generally benign.

Cardiac Pacemakers

The reliability and safety of implantable cardiac pacemakers is well established and continues to improve. In determining medical fitness, consideration must be given to the presence of any structural heart disease. Given the high degree of reliability of modern pacemaker systems, even pacemaker dependency need not restrict a pilot if the risk of failure is less than 2%/year. Each case will need to be considered individually and not before 3 months after successful implantation. Factors to be taken into consideration include potential environmental interference (low risk in cockpits today), device recalls and estimated battery longevity. Follow up for those with a pacemaker, which should take place every 6 months, requires a pacemaker clinic report including an indication of the underlying rhythm and escape rate.

Implanted Cardiac Defibrillators

It is highly improbable that an individual with an implanted cardiac defibrillator can be considered fit. However individual cases can be considered provided there is no structural heart disease and even in such cases only a restricted medical certification may be granted. Such restricted certification will not be considered before completion of a trial period of at least 6 months. During this time defibrillator function and cardiac response must be carefully monitored to ensure that any dysrhythmias are properly identified and promptly corrected without any incapacitation, and that there are no inappropriate shocks.

Chapter 4: Vascular Disorders

Dilated Ascending Aorta or Thoracic Aortic Aneurysm

The natural history of a dilated thoracic aorta and the risk of an incapacitating event such as aortic dissection or rupture is dependent on the specific etiology (degenerative disease, genetically mediated disease etc.), size of the aorta, rate of growth and individual body size among other factors. Individuals with a dilated aorta need to be evaluated on a case by case basis, but may be eligible for medical certification if the risk of rupture or dissection can be demonstrated to be less than 2% per year. Individuals with a bicuspid aortic valve and ascending aorta less than 45 mm in size, taking into account the individual's body size, with no family history of sudden death, aortic dissection or rupture may be eligible for medical certification. Annual follow-up is required and should include imaging of the dilated aorta.

Abdominal Aortic Aneurysm

Untreated aneurysms, even if asymptomatic are unlikely to be compatible with medical certification unless it can be demonstrated that the risk of rupture is less than 2% per year. Such low risk is associated with an aneurysmal size of less than 5 cm, the acceptable threshold being 4.5 cm.

The presence of an abdominal aneurysm in a middle-aged or older pilot raises concerns about the presence of co-existing conditions, particularly coronary artery disease. Modifiable risk factors particularly those which raise the risk of rupture such as hypertension must be controlled. Smoking must be eliminated. Prosthetic graft replacement

of diseased aortic aneurysms with no other evidence of risk will be considered on an individual basis.

Asymptomatic Carotid Bruit

Since the presence of a carotid bruit may indicate severe stenosis, it should lead to a carotid doppler examination. Likewise a cardiovascular assessment is required to rule out significant coronary artery disease. Significant stenosis (>75%) even asymptomatic is associated with a >33% risk of coronary events over 4 years and therefore renders the applicant unfit. Any stenosis that has been associated with a stroke or TIA will also make the applicant medically unfit.

Arterial Thrombosis

Individuals who have sustained an isolated, arterial thrombosis will be considered on an individual basis. Of particular concern are thromboses related to coagulopathies or other chronic predisposing conditions.

Venous Thrombosis

An isolated episode of deep venous thrombosis need not preclude medical certification provided there are no chronic predisposing conditions, and a minimum of 3 months have elapsed since the episode. Applicants with recurring episodes or with known predisposing factors will be considered on an individual basis only after 12 months

have elapsed since the last episode and their risk of recurrence is lowered by satisfactory anticoagulation. In such cases pilots will be considered for a restricted category. The latter requires demonstration of at least two therapeutic INR levels over a recent 1 month period.

Pulmonary Embolism

Applicants with an isolated episode of pulmonary embolism, without predisposing conditions for recurrence can be considered for relicensure after an interval of 3 months, provided there is no disabling, residual pulmonary hypertension, right ventricular function is normal and the risk of venous thrombosis and pulmonary embolism is decreased by appropriate treatment to an acceptable level.

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