

## CHAPTER 2 - CARDIOVASCULAR SYSTEM

### 1 INTRODUCTION

Over the past few years attitudes towards medical certification have been based increasingly on the risk of event. In certain conditions, however, the event may be of less prognostic importance than its physiological and/or psychological consequences. Thus, whereas it may not be difficult to predict the risk of cardiac death within a population, a more empirical assessment of the importance of symptoms is needed, for example, in paroxysmal atrial fibrillation which can have a variable effect both on different individuals, and on the same individual at different times.

The JAA Class 1 cardiovascular requirements are explicitly stated in JAR-FCL 3.130(a). Unrestricted Class 1 certification implies that there is no degradation of these requirements which are not attributable to age alone. It bears the implication that the licence holder is fit for single-pilot operations in which the medical cause accident rate is likely to equal the incapacitating event rate. In cardiovascular terms this event rate is highly age-dependent.

The assessment of fitness permitting multi-pilot, but not single-pilot, operation (as described in JAR-FCL Part 3 Appendix 1) is based on the target risk of major incapacitating event not exceeding a notional 1% per annum (i.e. one event in 8 760x100 or approximately in 1 in 10<sup>6</sup>). This represents the cardiovascular mortality of a 60–65 year old man in Northern Europe. This approach is justified by making certain assumptions relating to a target multi-pilot accident rate from medical cause of one catastrophe in every 10<sup>8</sup> – 10<sup>9</sup> flying hours, with a target overall fatal accident rate of 1 in 10<sup>7</sup> flying hours. It assumes some criticality of the flight envelope persisting for 10% or less of a total flight of average duration (i.e. 100 minutes) with a 1 in 10<sup>2</sup> chance of an incapacitating event during this period leading to an accident. If this incapacitating event occurs not more often than once in every 10<sup>6</sup> hours (i.e. once in every 100 years approximately or 1% risk of event/annum), then the fatal multi-pilot aircraft accident rate due to cardiovascular cause should not occur more frequently than in 10<sup>9</sup> hours. Accident statistics over the past 20 years suggest that this target is being achieved. Once a professional airman has a 1% major risk of incapacitating event per annum, or greater, then he/she will be unfit for duty. This objective, known as “the 1% rule” bears clarification. For each fatal myocardial infarction which occurs, there will be 1-3 non-fatal such events, likewise for each fatal stroke, there will be a non-fatal event rate which is factored round a cardiovascular mortality of 1% per annum. This also applies to other cardiovascular pathologies (i.e. valvular heart disease/arrhythmias) and not only to the ischaemic syndromes.

The JAA Class 2 requirements relate to private pilots. As most private flights are single-pilot operations, a fatal accident is likely to be the outcome of complete incapacitation from medical cause. Most fatal accidents involving private aircraft, however, are due to pilot error and until recently the rate approximates 1 in 4 x 10<sup>4</sup> flying hours. For Class 1 operations it has been suggested that only 1 in 10<sup>2</sup> single-pilot accidents should be attributable to medical cause. It would be appropriate to downgrade this to 1 in 25–50 for Class 2 operations, this lowered requirement having a resonance with the lower safety level of Class 2 operations as a whole. In this case the judgmental point becomes an anticipated event rate of one in 10<sup>6</sup> (i.e. 1 in 25 x 4 x 10<sup>4</sup>) hours, or 1% per annum. Thus the Class 2 target for unrestricted certification is necessarily more or less identical with the Class 1 ‘valid only as or with qualified co-pilot’ requirement (Class 1 ‘OML’). This means that only minor modification is needed to the Class 1 OML standard to apply it to the Class 2 standard. This is included in the boxed text.

Although there may be some doubt about the wisdom of a Class 2 limitation ‘valid only with safety pilot and in aircraft with dual controls’ (Class 2 ‘OSL’) on the certificate to allow private pilots with a lower standard of fitness to continue to hold a licence, it is possible to identify certain areas where this might safely be permitted. These are also dealt with in the boxed text.

Therefore, in the foregoing, ‘Class 1’ refers to the requirements permitting single-pilot commercial operation. Class 1 ‘OML’ deals with the requirements restricting an applicant to multi-pilot commercial operation only. Class 2 (which is essentially equivalent to Class 1 ‘OML’) applies to

the unrestricted certification of private pilots. Finally Class 2 'OSL' implies a restriction on the latter to fly with a type-rated safety pilot.

## **2 HYPERTENSION**

### **2.1 Hypertension and overall vascular risk**

Hypertension has been described as the most powerful and prevalent of all the coronary vascular risk factors and its impact on the health and certificability of professional flight crew is profound. Flight crew undergoing frequent medical examinations should be well placed for early intervention to minimise the effect of hypertension. Nevertheless, repeatedly moderate, and sometimes severe, hypertension is detected having apparently been missed or ignored by authorised medical examiners (AMEs). The explanation probably lies in part in a lack of appreciation of the likely additional cost in future health terms of untreated hypertension, and in part to a desire to avoid unnecessary interference which might have licensing implications.

Most hypertension in adults is "idiopathic" representing no doubt in part the genetic inheritance of the subject and his interaction with the environment. In Northern Europe, 15-25 % of middle aged males and females are above the World Health Organisation cut-off point (160/95mmHg). If the hypertension is particularly severe, or poorly controlled, then a cause should be sought although a correctable cause is rarely found.

In younger subjects, in their 20s and early 30s, however, there is a greater chance of finding an identifiable cause, which is quite likely to involve the kidneys. Renovascular abnormalities when corrected may not render the subject normotensive, although the blood pressure is sometimes easier to control. Renal investigation may include ultrasonic examination of the kidney and a MAG3 scan with or without captopril. Any difference in function should provoke further investigation, particularly in the young subject. This may include renal angiography. Pheochromocytoma is an extremely rare cause of hypertension and often not diagnosed during life. Other (metabolic) causes such as Conn's Syndrome are also rare.

Hypertensive subjects as a group do not have a normal prognosis, and this is worsened if other vascular risk factors are present. It has become increasingly recognised that high blood pressure may be associated with biochemical abnormalities such as insulin resistance and mixed lipid disorders (Reaven's syndrome), risk to the cardiovascular system being multiplicative. The significance of an elevated blood pressure should, therefore, be expressed in terms which include acknowledgement of the presence or absence of other vascular risk factors which include smoking, family history and obesity as well as those given above. Untreated hypertension multiplies the risk of the following conditions: Stroke - sevenfold, congestive heart failure-fourfold, myocardial infarction-threefold, and occlusive vascular disease-twofold.

### **2.2 Definition**

Treatment of hypertension has been shown to be beneficial at levels at and above a diastolic pressure of 90 mmHg, measured at the disappearance of the Korotkoff sounds (Phase V). The benefit of treatment at this level is not large. There is a difference in prognostic terms between 'casual' blood pressure recordings, such as may be made during a routine examination, and the 'basal' level which may be obtained as the mean of a number of observations, commonly on different occasions and sometimes after a period of rest. For certificatory purposes at least two readings of both systolic and diastolic pressure should be obtained. If the heart rate is increased then these should be repeated after an interval. So called 'white-coat' hypertension, representing an exaggerated alarm reaction is likely to be common in the pilot group and needs careful consideration. Here the clinical signs of established hypertension should be absent.

The value of a full clinical assessment by a cardiologist needs to be emphasised. The presence or absence of loss of compliance in the peripheral arterial wall is an important clinical observation in hypertension. Furthermore, vascular change in the fundus oculi such as silver wiring of the retinal arterioles, an increase in the arterio-venous ratio, or arterio-venous nicking are important signs. The last named, if present, is a sign of significant hypertension and it is unlikely that the subject would be fit for aircrew duties without further review. Echocardiography is of value in determining

an increase in the left ventricular muscle mass. Electrocardiography is not such a sensitive technique but left ventricular voltage hypertrophy with systolic overload is an important predictor of adverse outcome- it carried a 36% mortality at five years in the Framingham Study.

Neither displacement of the apex beat nor a fourth heart sound should be present. High sympathetic drive may be causal if a tachycardia is present. Multiple observations of the pressure on different occasions, preferably made by the personal physician, are also helpful. But ambulatory blood pressure monitoring should always be employed in cases of doubt. The diagnosis of "white coat hypertension" is not acceptable without such evaluation. Exercise electrocardiography is not indicated routinely.

The levels of systemic pressure permitted for certification purpose are just that. They are not treatment targets which should be judged on clinical grounds. It should be the objective in the management of hypertension in flight crew, as in others, to secure smooth reduction of elevated pressure in the absence of unwanted effects. Ambulatory blood pressure recording may enhance management but intervention levels based on mean pressures taken over 24-hours are not fully agreed. Recording devices should be of proven standard.

### 2.3 Investigation

When the diagnosis of hypertension (160/95-WHO) is made, an identifiable cause is unlikely to be present in more than about 5% of all subjects and a correctable cause in a much smaller percentage. All, however, should undergo at least serum creatinine, urea and electrolyte, fasting cholesterol (total and HDL component), triglyceride, urate and glucose estimation. If the hypertension is unusually severe or difficult to control, or the patient is young (<40 years) then intravenous urography, renal scintigraphy and/or renal angiography and urinary catecholamine excretion measurement may be indicated. Plasma renin concentration, abdominal ultrasonography (for aortic calibre and renal outline) and Captopril MAG3 study may be appropriate.

### 2.4 Treatment

Non-pharmacological methods of treatment should be adopted initially to encourage involvement by the airman in health maintenance. Attention should be paid to the achievement of an optimum body weight. A reduction in alcohol consumption to no more than two units per day will be beneficial. Other techniques include restriction of sodium intake, enhanced potassium consumption, increased exercise and relaxation training, although the benefits are likely to be small.

Until recently the only treatment permitted by ICAO and most certificatory agencies included non-loop diuretics and beta-blocking agents. Diuretics have drawbacks in metabolic terms – elevation of the plasma triglyceride, of plasma urate and impairment of glucose metabolism for example. Loop diuretics are to be avoided on account of their short duration of action. Unwanted effects such as headache, cramp, muscle aches and loss of potency also occur. Many beta-blocking agents also have minor adverse metabolic effects and tend to cause drowsiness and fatigue, even if hydrophilic. Propranolol was the first beta-blocking drug permitted in flight crew but is to be avoided as it has a higher side effect profile than some of the newer agents. This, in part, reflects variation between individuals in its metabolism. Atenolol is probably the most widely used beta-blocking agent and can be given at a dose of not more than 50mg om. It may be combined with a diuretic agent. The use of centrally acting antihypertensive agents such as methyldopa, clonidine and reserpine, together with the ganglionic and post-ganglionic agents, such as bethanidine and guanethidine, disqualify from any form of certification to fly. The sensitive alpha blocking agents such as prazosin should be avoided.

Recently a consensus has developed which suggests that the angiotensin converting enzyme (ACE) inhibitors and the slow channel calcium-blocking agents are acceptable for use by flight crew subject to careful supervision. These groups of products do not appear to cause central nervous system effects that are of significance and may be used under supervision either alone or

combined with other agents such as non-loop diuretics. The possibility of a first dose effect requires consideration with any ACE inhibitor and the dosage may need to be reduced in the event of sodium depletion from whatever cause. This includes diarrhoea and feverish illness. The slow-channel calcium-blocking agents are associated with flushing and headache but combination with a beta-blocking agent may reduce these side effects. The longer acting products (i.e., amlodipine) are to be preferred to shorter acting ones (i.e. nifedipine). Verapamil and diltiazem may also be considered but not in concert with a beta-blocking agent. A new group of agents, the sartans (losartan, valsartan, candesartan), which block the angiotensin II AT 1 receptor have a very low side effect profile and are promising new additions in the treatment of hypertension in aviators. Experience is currently being gained.

During the institution of treatment and its regulation, an airman should be made temporarily unfit and a note made of any adverse effects of medication. Before the resumption of duties, if the treatment has been instituted with a product with potential side-effects such as a beta-blocking agent, the satisfactory completion of an appropriate 'base check' is required. The airman should be restricted to multi-pilot operations (Class 1 'OML') unless it can be demonstrated that his overall risk of cardiovascular event, taking into account his age, treated and untreated blood pressure levels and any other vascular risk factor presence, is normal or near normal in actuarial terms.

### **3 LIPID ABNORMALITIES**

Inherited abnormalities of lipid metabolism are not uncommon. Certain examples, such as familial hypercholesterolaemia (Fredrickson Type IIa) occurs in about 2-3/1 000 of the population and have profound implications for the cardiovascular system. The cholesterol may be elevated to 10 mmol/L (385 mg%) or more and 50% of male patients suffering this disorder will have manifestations of coronary artery disease by the age of 50. Once identified such individuals need to be treated aggressively with ion-exchange resins or fibrates and/or an HMG CoA reductase inhibitor. As with hypertension, even minor elevations of the plasma cholesterol have an effect on cardiovascular health and it is recommended that special attention be paid to diet and body weight when the level exceeds 5.5 mmol/L (215 mg%). Above 6.5 mmol/L (255 mg%) pharmacological intervention may be indicated if weight reduction and dietary manipulation have failed. Minor elevation of triglyceride should yield to weight and/or alcohol reduction. More substantial elevations (>4.0 mmol/L (>350 mg/dL)) will require specialist review. JAR-FCL 3.130 and 3.250 require routine investigation of the plasma lipids, if other risk factors are present. There is no requirement as such to review the individual fractions of high density and low density lipoprotein cholesterol, but a high density fraction less than 1.0 mmol/L may be associated with additional vascular risk on account of loss of the protective effect of this moiety.

Treatment of a lipid disorder is not a bar to certification and no restriction, per se, is required on the medical certificate unless the overall vascular risk is considered to be too great. From the point of view of overall risk, a European in his 50's probably has a median risk of major coronary event of one every  $3 \times 10^6$  flying hours but the presence of hypertension, lipid abnormality and/or smoking may increase this to one in every  $2 \times 10^5$  hours. In spite of this, membership of a high risk group does not necessarily extend to an individual in that group, but three fifths of major coronary events will occur within the top quintile of risk. Unfortunately, intervention to reduce risk factor presence is only likely to bring about at best a 30% reduction in risk when compared with age matched controls. The discovery of elevated plasma lipids should thus prompt careful review of the blood pressure and attention to other risk factors such as minor hypertension, smoking and glucose intolerance. This is particularly important in single-pilot operations. In this situation regular cardiological review with exercise electrocardiography is justified.

## **4 CORONARY ARTERY DISEASE**

### **4.1 General considerations**

Diseases of the circulation are an important and in many countries the single most important cause of death. In North West Europe the number of deaths from diseases of the circulation approaches the number of deaths from all other causes put together. There is, however, evidence of a decline in the death rate from coronary heart disease in a number of countries including some which are JAA signatories. In certain countries in the Third World however, increased living standards appear to be associated with an increased incidence of coronary artery events.

In addition to variation in the prevalence of coronary artery disease between countries, there is variation between regions within the same country but these are not however sufficiently large to have certificatory implications. The recommendations with regard to re-certification following a cardiovascular event or intervention are based on available data, and the current practice by a number of ICAO and JAA signatory nations.

The coronary syndromes are capricious in their presentation and potentially devastating in their outcome. In Northern Europe myocardial infarction will be the cause of death in between one quarter and one third of the entire population, significant numbers dying before reaching age 65. One sixth of new cases of coronary heart disease will die suddenly without symptoms recognised to be premonitory. A further two fifths each will present with myocardial infarction or angina pectoris. Coronary artery disease predicts coronary events and one third of subjects suffering a myocardial infarction will die within 28 days, half of the deaths occurring within the first 15 minutes after the onset of symptoms.

Demonstrated coronary artery disease thus has to be treated warily in the certificatory environment. Angiographic data are powerful predictors of future cardiac events in proven or suspected coronary artery disease and although long used as the so-called "gold standard" an assessment should be properly made with full clinical biochemical and exercise electrocardiographic/scintigraphic evaluation. No ischaemic burden is tolerable for certificatory purposes.

Left main stem or triple vessel coronary artery disease disqualifies from certification. Single or two vessel involvement may be considered for Class 1 OML provided the coronary angiogram shows no more than 30% luminal narrowing in any major epicardial vessel in the presence of a normal contrast ventriculogram. There shall also be no demonstrable evidence of myocardial ischaemia on exercise electrocardiography /scintigraphy. Luminal obstruction >30% but < 50% in a minor vessel may be tolerable provided there is no subjective or objective evidence of myocardial ischaemia and provided the contrast ventriculogram remains normal.

## 4.2 **Electrocardiography**

### a *Minor repolarisation anomalies*

Minor repolarisation anomalies involving mainly the ST segments and T-waves are seen in 2-3% of asymptomatic males with flying status. Exercise ECG should be used to clarify such anomalies which have a low predictive value for coronary artery disease, although with increasing age the overall prevalence of such disease is greater. Nevertheless, in spite of shortcomings, the walking time of the exercise ECG (which should be symptom-limited) is predictive of outcome notwithstanding the appearance of the ECG (see b below).

### b *Exercise electrocardiography*

Exercise electrocardiography should not be used routinely. It is now accepted that the problem of limited specificity of the technique makes the likelihood of a 'false positive' exercise recording several times as great as a 'true positive' one in the average middle-aged asymptomatic pilot. It may, however, still be indicated when the vascular risk factor presence in terms of hypertension and/or hyperlipidaemia is such that the probability of cardiovascular event becomes excessive. Even so, a negative exercise recording may not permit a confident decision to certificate without restriction to multi-pilot operation in such circumstances. Furthermore, an abnormal response in hypertensive subjects may not necessarily indicate coronary artery disease.

Exercise ECG should be carried out to a standard treadmill protocol, preferably that of Bruce, although the 20 watt bicycle ergometric protocol equivalent may also be used. The test should be symptom-limited where possible, i.e., taken to exhaustion or onset of other symptom and a 12-lead recording system should be used which is optimally damped. Single lead bipolar or unipolar systems are not acceptable. Dedicated exercise electrocardiographic systems are available which help overcome the problem of muscle induced artefact.

#### 4.3 **Minor coronary disease**

It is likely that significant coronary artery disease will declare itself as angina pectoris or myocardial infarction (see below). Minor coronary artery disease comes to light in a number of ways, sometimes following angiography for atypical chest pain, sometimes following minor and often irrelevant electrocardiographic findings.

For certificatory purposes subjects with asymptomatic minor coronary artery disease are acceptable for multi-pilot operation provided that:

- a A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no evidence of myocardial ischaemia. Cardioactive medication (betablocking agents/vasodilators) ideally will have been withdrawn 48-hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of a conduction disturbance in the resting electrocardiogram;
- b echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction  $\geq$  0.50 without significant abnormality of wall motion such as dyskinesia, hypokinesia or akinesia.
- c no major epicardial artery has a stenosis  $>$ 30% and no minor vessel  $>$ 50%;
- d appropriate intervention against vascular risk factors such as elevated cholesterol and hypertension has been undertaken;
- e follow-up every six months or annually by a cardiologist acceptable to the AMS with symptom-limited exercise electrocardiography is carried out as appropriate;
- f in the majority of cases recertification will be restricted to multi-pilot operation (Class 1 'OML').

***This level of assessment applies also to Class 2. More significant disease is acceptable for Class 2 'OSL' only if symptom-limited exercise ECG/ scintigraphy/stress echocardiography fails to suggest myocardial ischaemia. Evidence of exercise induced myocardial ischaemia disqualifies from all classes of certification to fly.***

#### 4.4 **Angina pectoris**

Angina pectoris, as a potential cause of subtle incapacitation, disqualifies from all classes of certification to fly, irrespective of whether it is abolished or not by medication. This is independent of whether the symptoms are due to obstructive coronary artery disease (which will in all probability be disbaring in its own right) or to coronary arterial spasm giving rise to variant (Prinzmetal) angina. Other causes of angina pectoris (i.e., aortic stenosis, hypertrophic (or dilated) cardiomyopathy) also disqualify.

#### 4.5 **Chest pain of doubtful cause**

Chest pain of uncertain cause is uncommon in professional flight crew but requires full investigation including symptom-limited exercise electrocardiography and/or scintigraphy/stress echocardiography. Coronary arteriography is useful in doubtful cases. If the coronary arterial tree and left ventricular performance are within normal limits then the prognosis should be as good as that of the airman's uninvestigated peers. Certification requires a judgement on the severity of the

symptoms and their likely effect. The possibility of other cardiac (i.e., mitral leaflet prolapse) or non-cardiac explanation for such symptoms should be sought.

#### 4.6 Myocardial infarction

The early prognosis following myocardial infarction improves exponentially from the point of onset of symptoms. The intermediate and longer term outcome correlate powerfully with residual left ventricular function and with coronary anatomy. The prediction of coronary events from the appearance of the coronary angiogram is not straightforward. Much has been learnt in recent years about the composition of atheromatous plaques, their pathophysiological behaviour and their anatomy. Loss of stability appears to be associated with the thinning of the fibrous tissue covering the core of the plaque. This may be associated with rupture and clot formation leading to an unstable ischaemic syndrome or myocardial infarction. Contrary to what was initially believed, it cannot be assumed that the more severe stenoses carry a worse outlook as not infrequently it is the less severe stenoses which undergo plaque rupture and subsequent occlusion of the vessel with thrombus. The epidemiological data, however, have all suggested that provided there is no lesion greater than 30% in any major epicardial artery, the 5 year prognosis in terms of coronary event is sufficiently good to permit restricted Class 1 certification. The following recommendations are based upon those data. Thus, although myocardial infarction disqualifies from certification to fly for at least six months following the index event, asymptomatic subjects may be considered for recertification for multi-pilot operation not sooner than six months following the event, provided that

- a A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no evidence of myocardial ischaemia. Cardioactive medication (betablocking agents, vasolidators) ideally will have been withdrawn 48-hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an abnormality in the resting ECG;
- b echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction  $\geq$  0.50 without significant abnormality of wall motion such as dyskinesia, hypokinesia or akinesia.
- c a 24-hour ambulatory ECG demonstrates no significant rhythm or conduction disturbance (see also paragraph 14);
- d recent coronary angiography (i.e. at least six months after the event and not more than six months prior to review) demonstrates no stenosis in any vessel remote from the myocardial infarction  $>$ 30% and no demonstrable functional impairment of the myocardium subtended by any such vessel. It is important to establish, in so far as is possible, that the infarction has been 'completed' and that a tight stenosis, which may or may not represent recanalisation of a blocked vessel is not subtending potentially ischaemic muscle. This is generally best demonstrated by exercise scintigraphy;
- e appropriate intervention against vascular risk factors such as elevated cholesterol and hypertension has been undertaken;
- f annual follow-up by a cardiologist acceptable to the AMS with exercise ECG/scintigraphy is carried out as appropriate. A further angiogram is required no later than five years following the index event unless exercise electrocardiography is impeccable and shows no change on annual evaluation; ECG
- g recertification is restricted to multi-pilot operation (Class 1 'OML').

***[This level of assessment applies also to Class 2. Should post-event coronary angiography not be available, the applicant shall be restricted to Class 2 'OSL' provided that symptom-limited exercise ECG/scintigraphy/stress echocardiography fails to suggest myocardial ischaemia. Evidence of exercise induced myocardial ischaemia disqualifies from all classes of certification to fly.]***

#### 4.7 Coronary artery bypass grafting (CABG)

The intermediate and long term prognosis following coronary artery bypass grafting has been reported widely. There is a procedure-related mortality of 0.5-2% with a small risk of peri-operative myocardial infarction or cerebrovascular event. First year graft occlusion occurs at a rate of about 10% falling to 1–3% per annum subsequently. As time goes by, obstructive coronary disease progresses in the native circulation and after 10 years 50% of saphenous bypass grafts will have obstructed. Efforts towards secondary prevention to reduce any risk factor are required. The reduction of elevated levels of cholesterol in particular has been demonstrated to have a beneficial effect on the outcome. Intervention against a low density lipoprotein cholesterol level >4.0mmol/L with a statin (simvastatin, pravastatin) should be undertaken, unless there is any contraindication. The left internal mammary artery grafted into the left anterior descending coronary artery or its first diagonal branch appears particularly durable with a reported 10-year survival better than 90%. However up to 50% of patients undergoing coronary artery bypass grafting for angina pectoris are likely to experience a recurrence of their symptoms after six or seven years.

Asymptomatic subjects may be considered for re-certification not sooner than six months after surgery, provided that:

- a A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no evidence of myocardial ischaemia. Cardioactive medication (betablocking agents, vasodilators) ideally will have been withdrawn 48-hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an abnormality in the resting ECG;
- b echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction  $\geq$  0.50 without significant abnormality of wall motion;
- c a 24-hour ambulatory ECG demonstrates no significant conduction disturbance, nor complex, nor sustained rhythm disturbance, nor evidence of myocardial ischaemia (see paragraph 13);
- d recent coronary angiography (i.e. at least six months after the procedure and no more than six months prior to the review) demonstrates patent grafts with a good runoff. There shall be no proximal disease in any ungrafted vessel  $>$ 30% and no demonstrable impairment of the myocardium subtended by any such vessel. There shall be no obstruction in any graft or of its anastomosis  $>$ 30%;
- e appropriate intervention against vascular risk factors such as elevated cholesterol and hypertension has been undertaken;
- f annual follow-up by a cardiologist acceptable to the AMS with exercise ECG/scintigraphy/stress echocardiography is carried out as appropriate. Five yearly coronary angiography should be considered after surgery but may not be necessary if the exercise ECG shows no change on annual evaluation and is acceptable to the AMS;
- g recertification is restricted to multi-pilot operation (Class 1 'OML').

***This level of assessment applies also to Class 2. Should post-intervention coronary angiography not be available, the applicant should be restricted to Class 2 'OSL' provided symptom-limited exercise ECG/scintigraphy/stress echocardiography fails to suggest myocardial ischaemia. Evidence of exercise induced myocardial ischaemia disqualifies from all classes of certification to fly.***

#### 4.8 Percutaneous trans luminal coronary angioplasty (PTCA)

A significant minority of flight crew with coronary artery disease requiring revascularisation are suitable for angioplasty/stenting. This includes individuals who have developed a stenosis in a coronary arterial bypass graft. If the patient has multi-vessel disease, the risks of intervention and recurrence are higher. Re-stenosis occurs in up to 20%-30% of patients in the first 6 months and

is frequently associated with the recurrence of symptoms. Thereafter the restenosis rate is lower, but still appreciable - 38% overall at 30 months in one study.

A number of international trials have examined whether angioplasty or coronary artery bypass grafting is the procedure of election in the management of certain categories of coronary artery disease; whilst others are examining the significant prognostic gains demonstrated by lipid lowering strategies, notably with statins. At present the indications for re-certification following angioplasty are broadly those for coronary artery bypass grafting. Asymptomatic subjects may be considered for re-certification to fly following single vessel (i.e. not a graft) transluminal coronary angioplasty with or without stenting, at least six months following intervention, provided that:

- a A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no evidence of myocardial ischaemia. Cardioactive medication (beta-blocking agent, vasolidators) ideally will have been withdrawn 48 hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an abnormality in the resting ECG;
- b echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction  $\geq$  0.50 without significant abnormality of wall motion;
- c a 24-hour ambulatory ECG demonstrates no significant conduction disturbance, nor complex, nor sustained rhythm disturbance, nor evidence of myocardial ischaemia (see paragraph 13);
- d recent coronary angiography (i.e. at least six months after the procedure and not more than six months prior to review) demonstrates no stenosis  $>$ 30% in any major epicardial artery and no significant change in the subject vessel when compared with the immediate post intervention angiographic appearance;
- e appropriate intervention against vascular risk factors such as elevated cholesterol and hypertension has been undertaken;
- f annual follow-up by a cardiologist acceptable to the AMS with exercise ECG/scintigraphy/stress echocardiography is carried out as appropriate. Five yearly coronary angiography should be considered after the index intervention but may not be necessary if the exercise ECG shows no change on annual evaluation and is acceptable to the AMS. Particular attention should be paid if multi lesion same vessel and multi vessel coronary angioplasty/stenting was performed.
- h recertification is restricted to multi-pilot operation (Class 1 'OML').

***This level of assessment applies also to Class 2. Should post-event coronary angiography not be available, the applicant shall be restricted to Class 2 'OSL' provided symptom-limited exercise ECG/scintigraphy/stress echocardiography fails to suggest myocardial ischaemia. Evidence of exercise induced myocardial ischaemia disqualifies from all classes of certification to fly. Subjects with demonstrated coronary disease would be expected to be receiving low dose aspirin (75-150 mg) unless there is a specific contraindication.***

## 5 AORTIC ANEURYSM

The prognosis in aortic aneurysm is related to the diameter of the affected segment. About half of all in the abdomen  $>$ 6.0 cms rupture within one year while one sixth rupture over a similar period if the diameter is  $<$ 6.0 cms. Data are fewer for thoracic aortic aneurysm but about two thirds, only, survive five years, rupture occurring in one third of those dying over this period. Surgical correction may stabilise the situation but does not correct remote pathology.

The diagnosis of aortic aneurysm in any part of the thoracic aorta, irrespective of cause, whether before or after surgical repair, disqualifies from certification to fly.

***Following satisfactory repair of an abdominal aortic aneurysm, a normotensive applicant with a satisfactory exercise electrocardiographic response may be considered for Class 2 certification, with annual review by the AMS, the review to include ultrasonic examination of the abdominal aorta.***

## **6 MARFAN'S SYNDROME & RELATED DISORDERS**

Marfan's syndrome is usually transmitted via an autosomal dominant gene with variable expression. In about 15% of subjects it appears to be due to a mutant gene. Its prevalence is approximately 1-5/100 000 of the population which is adjacent to that of the somewhat similar Ehlers-Danlos syndrome. In view of the risk of progressive aortic and/or mitral regurgitation and of post-operative aortic rupture it is incompatible with both Class 1 and Class 1 'OML' status. Applicants with a forme fruste showing no evidence of aortic aneurysm formation on MRI scanning, or of no more than minor aortic or mitral regurgitation on 2D Doppler echocardiography all other echocardiographic measurements being within the normal range may be considered for Class 1 'OML' subject to annual cardiological follow up.

***This level of assessment also applies to Class 2. Applicants unable to meet the above requirements may be considered for Class 2 'OSL' provided the diameter of the ascending aorta remains < 4.0 cms and that of the abdominal aorta < 5.0 cms. Mild aortic/mitral regurgitation may be acceptable in this context.***

## **7 [PERIPHERAL ARTERIAL DISEASE]**

Peripheral arterial disease is powerfully predictive of a wider spread arteriopathy involving the coronary and cerebral arteries. Once the diagnosis has been made cardiological assessment is required, including exercise ECG/scintigraphy/stress echocardiography. This may be of limited sensitivity if the end point is lower extremity claudicant pain. In that case further investigation including coronary angiography will be warranted. A careful search should also be made for carotid artery bruits and 2D Doppler or digital subtraction studies should be carried out on the carotid circulation (see also section III). Cranial artery disease is disqualifying from all classes of certification to fly.

***This level of assessment also applies to Class 2. Should coronary angiography not be available, the applicant may be issued with a Class 2 'OSL' certificate provided at least three stages of the Bruce protocol can be completed without abnormality in the exercise ECG. Other methods of detecting myocardial ischaemia may be acceptable, such as dobutamine or adenosine stress ECG/echocardiography.***

## **8 VALVULAR HEART DISEASE**

Chronic rheumatic heart disease is of declining importance in Europe and problems such as bicuspid aortic valve and mitral leaflet prolapse are becoming much more commonly diagnosed, being seen in 1% and 5–8% of the population respectively.

### **8.1 Flow (innocent) murmurs**

Systolic ejection murmurs in the young and slim are very common and should be reviewed by a cardiologist. They are normally early and brief and are not associated with an ejection sound or early diastolic murmur. Usually a single cardiological consultation will establish the innocence of an unidentified murmur, but 2D Doppler echocardiography will be required in cases of doubt.

### **8.2 Aortic valve disease**

a *Bicuspid aortic valve*

This is a common congenital abnormality and may be associated with abnormality of the aortic root. It affects up to 1% of the adult population in Europe. In view of the risk of progression to aortic stenosis or regurgitation or both, cardiological review should be carried out annually. In addition to the risk of progression to aortic stenosis or regurgitation, there is a risk of endocarditis. An enhanced risk of this insidious condition is not a reason for denial of certification but subjects with a bicuspid aortic valve need to pay attention to dental hygiene and receive prophylactic antibiotics. Provided there is no known sensitivity, usually 3g amoxicillin is taken orally one hour beforehand. The same applies to urinary tract manipulation (see 8.5). It is uncommon for significant valvular abnormality to be present before the fifth decade. Provided no other abnormality (2D Doppler flow rate <2.0m/sec) is present it may be consistent with unrestricted certification. If the aortic root is 3.8 cms or greater, the applicant should be restricted to Class 1 'OML' and annual review by a cardiologist acceptable to the AMS. An aortic root diameter >4.0 cm is disqualifying all classes.

***This level of assessment also applies to Class 2. Minor degrees of dilatation of the aortic root in the presence of a bicuspid valve may be consistent with Class 2 'OSL'.***

b *Aortic stenosis*

Mild aortic stenosis (Doppler flow rate <2.0m/sec), provided good signals are obtained at echocardiography, is acceptable for Class 1 OML. The applicant should be capable of exercising to Bruce stage IV without symptoms. The risk of embolism from platelet aggregation on the closure line of the valve cusps, and of endocarditis make this restriction necessary. Significant deterioration of a bicuspid aortic valve usually does not occur before the fifth decade of life when either stenosis or regurgitation may become increasingly important. No significant left ventricular hypertrophy nor dilatation is permitted and the free wall and septal thickness shall not exceed 1.1 cm. A history of transient ischaemic attack (TIA) shall disqualify from all classes of certification. Annual review by a cardiologist acceptable to the AMS with 2D Doppler echocardiography is required.

***This level of assessment also applies to Class 2. In the absence of a history of peripheral embolism, applicants with a 2D Doppler flow rate <3.0m/sec without other abnormality of the resting electrocardiogram or echocardiogram, may be considered for Class 2 'OSL'.***

c *Aortic regurgitation*

Aortic regurgitation is well tolerated and even moderate regurgitation may be present for very many years. Minor regurgitation in the absence of aortic root disease may be compatible with unrestricted certification to fly but requires regular review by a cardiologist acceptable to the AMS with 2D Doppler echocardiography. The applicant should be capable of exercise to Bruce stage IV without symptoms. Co-existent dilatation of the aortic root (>4.0 cms) disqualifies from certification to fly. Evidence of volume overloading of the left ventricle (left ventricular end diastolic dilatation >6.0 cm) disqualifies although minor increase in the left ventricular end diastolic diameter may continue to be compatible with Class 1 'OML'.

***This level of assessment also applies to Class 2. A more significant increase in the left ventricular end diastolic diameter without an increase in the left ventricular end systolic diameter may be consistent with Class 2 'OSL' certification.***

8.3 **Mitral valve disease**

a *Rheumatic mitral stenosis*

Rheumatic mitral stenosis and/or regurgitation, once diagnosed, disqualifies from certification to fly in view of the risk of abrupt onset of atrial fibrillation and of cerebral embolism. The onset of atrial fibrillation may be at a fast rate, which in the presence of mitral stenosis, can provoke syncope and may be associated with pulmonary edema.

***This level of assessment also applies to Class 2. Applicants with mild mitral stenosis (valve area >2.0cm<sup>2</sup>) in sinus rhythm may be considered for Class 2 'OSL'.***

b *Mitral regurgitation/leaflet prolapse*

Mitral regurgitation has numerous causes, both congenital and acquired. Not uncommonly it is due to prolapse of a leaflet of the mitral valve, and much less commonly in Europe, to chronic rheumatic involvement. Mitral leaflet prolapse may be associated with atypical chest pain and atrial and ventricular rhythm disturbances. If frequent atrial or ventricular rhythm disturbances (>2% of normal complexes) are detected on routine electrocardiography, 24-hour ambulatory ECG and echocardiography are indicated together with exercise ECG as required in paragraph 8.4 b. There is a very small risk of cerebral embolus, chordal rupture and sudden cardiac death. Patients with an isolated mid-systolic click need no special restriction but the presence of mitral regurgitation secondary to mitral leaflet prolapse requires restriction to multi-pilot operation (Class 1 'OML'). Significant mitral regurgitation as evidenced by left ventricular end diastolic dilatation of the heart above 6.0 cm and/or systolic dimension above 4.1 cm or left atrial internal diameter above 4.5 cm shall disqualify. Any reduction of left ventricular function should be closely scrutinised or certification denied. The embolic stroke risk has been reported as increasing after 45 years of age, sharply in the presence of atrial fibrillation. The co-existence of mitral regurgitation and atrial fibrillation is in general terms an indication for treatment with warfarin which disqualifies from all forms of certification. A history of transient ischaemic attack (TIA) shall likewise disqualify from all classes of certification. Annual review by a cardiologist acceptable to the AMS including echocardiography is required.

Other causes of mitral regurgitation (i.e. rheumatic or degenerative) are normally disqualifying. Restricted certification (Class 1 'OML') may be considered in the absence of other abnormality only if the 2D Doppler echocardiogram demonstrates normal left ventricular dimensions and normal myocardial performance is confirmed by symptom-limited exercise electrocardiography to Bruce stage IV.

***This level of assessment also applies to Class 2. More than minor degrees of non-rheumatic mitral regurgitation should be restricted to Class 2 'OSL'. Significant mitral regurgitation and/or a history of transient ischaemic attack (TIA) disqualifies from all classes of certification to fly.***

8.4 **Valvular surgery**

a *Mechanical valves*

Mechanical valves, such as the Starr Edwards ball, and the Bjork-Shiley tilting disc prostheses in any position disqualify from all forms of certification to fly on account of the risk of embolic incident. The performance of the St Jude Medical pyrolytic carbon valve may be haemodynamically superior to the first two but is also disqualifying on account of the requirement for continuous anticoagulant treatment.

***This level of assessment also applies to Class 2.***

b *Tissue valves*

Only a prosthesis in the aortic position can be considered, the outcome and embolic risk following the insertion of a mitral prosthesis being incompatible with certification. The

xenograft valves, such as the Hancock and the Carpentier-Edwards prosthesis have a >1% per annum risk of embolism and endocarditis. The unmounted homograft valve in the aortic position has the lowest risk of such complications. All tissue valves deteriorate with age and this occurs more sharply after five years. Such valves may be less durable in younger subjects. The valve of choice is the unmounted homograft aortic valve in the aortic position. Candidates who have had a Carpentier Edwards, Hancock or similar bioprosthesis inserted into the aortic position may also be considered. A poorer prognosis and a higher thromboembolic risk is associated with mitral valve replacement. Asymptomatic subjects, who have undergone valve replacement/repair with a tissue valve, may be considered for recertification provided that:

- i A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no significant abnormality nor evidence of myocardial ischaemia. Cardioactive medication (beta-blocking agents/vasodilator) ideally will have been withdrawn 48 hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an abnormality in the resting ECG;
  - ii normal valve function is demonstrated by 2D Doppler echocardiography, which demonstrates a left ventricular ejection fraction  $\geq$  0.50 without significant abnormality of wall motion such as dyskinesia, hypokinesia and akinesia;
  - iii there is no significant coronary artery disease as defined in section 4.3. If coronary artery by-pass grafting was carried out at the time of surgery, section 4.7 also applies;
  - iv there is no history of systemic embolus;
  - v a 24-hour ambulatory ECG demonstrates no significant conduction disturbance nor complex, nor sustained rhythm disturbance nor evidence of myocardial ischaemia (see paragraph 13);
  - vi annual follow-up by a cardiologist acceptable to the AMS together with exercise ECG/scintigraphy/stress echocardiography and 2D Doppler echocardiography is carried out as appropriate;
  - vii recertification is restricted to multi-pilot operation (Class 1 'OML').
- c Reconstruction of a floppy mitral valve can achieve good results with a low risk of embolism if the left atrial appendage is resected. This procedure is consistent with recertification to fly subject to the recommendations given above.

***This level of assessment also applies to Class 2. Applicants failing to comply with the above standards, who, for example, have minor degrees of impairment of left ventricular function on 2D Doppler echocardiography may be considered for Class 2 'OSL'.***

- d The results following aortic valvotomy are not sufficiently reliable to permit any form of certification to fly.

#### 8.5 Antibiotic prophylaxis

Subjects with congenital or valvular abnormalities of the heart require antibiotic cover for both dental and urinary tract manipulation in line with current recommendations. This particularly refers to patients with prosthetic valves or a past history of endocarditis. The current recommendation is that 3 gms of amoxicillin be taken one hour before such procedure provided the patient is not penicillin sensitive. In that case erythromycin may be used at a dose of 1.5 gms followed by 0.5 gms six hours later. If there is a history of endocarditis an intravenous regime which includes gentamycin is currently recommended assuming there is no known drug sensitivity. Current guidelines should be followed.

## 9 VENOUS THROMBOEMBOLISM AND ANTICOAGULATION

## 9.1 Venous thrombosis

Isolated deep venous thrombosis with pulmonary thromboembolism is rare in fit patients of flight crew age. It has been described, however, following prolonged journeys by air but causative factors may include recent surgery, trauma, pregnancy, occult neoplasm, clotting abnormalities and previous deep venous thrombosis.

The diagnosis of deep venous thrombosis/pulmonary embolism needs to be secure. Phlebography, ventilation and perfusion (V/Q) scanning and pulmonary angiography may be required. In the event of the diagnosis being made, treatment with anticoagulants is indicated and is disqualifying (see paragraph 5.1, Chapter Haematology). Flying status should be denied until the product has been discontinued. If previous thromboembolism is suspected, it is necessary to ensure that there is no concomitant pulmonary hypertension (>30 mmHg systolic) and full evaluation shall be required. Pulmonary angiography may be justified.

Six-monthly follow up should be required following recertification which shall be restricted to Class 1 'OML' for the first two years. Initial annual follow-up by a cardiologist acceptable to the AMS should be required. Anticoagulation with warfarin or coumarin like substances disqualifies from all forms of certification to fly.

***This level of assessment also applies to Class 2.***

## 9.2 Use of aspirin

Aspirin is normally prescribed on a regular basis in the management of the coronary syndromes before and after intervention. It also may provide some protection against the risk of cerebral embolism in rhythm disturbances and valvular heart disease. It is also given in the presence of a muscle bridge in the myocardium.

Aspirin, 75-300mg, is a permitted substance provided there is no otherwise disqualifying condition. Its use should be regarded as 'usual care' and not be pivotal in reaching a certification decision, for example, to reduce the risk of thromboembolism.

## 10 MYOCARDITIS

There are a number of different causes of myocarditis which include infection, often with the Coxsackie A & B groups of viruses, bacteria and their toxins, protozoa and fungi. Certain drugs (i.e., the anthracyclines), organic (i.e., halogenated hydrocarbons) and inorganic compounds (i.e., carbon monoxide) may damage the myocardium, as may certain allergic reactions.

The most likely cause in flight crew will be a virus which runs a limited time course, often of weeks. The diagnosis is often missed although rhythm or conduction disturbance with evidence of impaired left and/or right ventricular performance should encourage its consideration. In the case of previous anthracycline administration i.e. for malignant disease, the impact on the myocardium may be significantly delayed and a risk of ventricular arrhythmia/sudden cardiac death remains indefinitely. Recertification is possible no sooner than six months following complete recovery from the illness, provided that:

- a A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no significant abnormality or evidence of myocardial ischaemia. Cardioactive medication (beta-blocking agents, vasodilators) ideally will have been withdrawn 48 hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an abnormality in the resting ECG;
- b echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction ? 0.50 without significant abnormality of wall motion such as dyskinesia, hypokinesia or akinesia;
- c a 24-hour ambulatory ECG demonstrates no significant conduction disturbance nor complex, nor sustained rhythm disturbance, nor evidence of myocardial ischaemia;

- d there is no history of systemic embolus;
- e six monthly follow-up by a cardiologist acceptable to the AMS with exercise ECG/scintigraphy/stress echocardiography and 2D Doppler echocardiography should be carried out until complete stability has been demonstrated;
- f in the majority of cases restriction to multi-pilot operation (Class 1 'OML') will be required for some years, especially following anthracycline administration.

An uncertain number of patients suffering a virus myocarditis progress, over a period of months or years, to dilated cardiomyopathy (see below).

***This level of assessment also applies to Class 2 and Class 2 'OSL'.***

## 11 PERICARDITIS

The causes of pericarditis include infection, neoplasia, myocardial infarction, collagen vascular disease, metabolic abnormality and hypersensitivity to certain pharmaceutical agents. Fitness to fly will reflect the underlying cause of the condition and whether or not its course is self limiting.

### 11.1 Acute benign aseptic pericarditis

Acute benign aseptic pericarditis is a febrile illness often presenting in young adults and characterised by chest pain, diffuse electrocardiographic change and sometimes breathlessness. It is a generally benign condition which may recur within the first few months after recovery. During acute illness an airman should be made temporarily unfit but recertification is possible three to six months following full recovery, provided that:

- a A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no significant abnormality or evidence of myocardial ischaemia. Cardioactive medication (beta-blocking agents/vasodilators) ideally will have been withdrawn 48 hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an abnormality in the resting ECG;
- b echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction  $\geq$  0.50 without significant abnormality of wall motion such as dyskinesia, hypokinesia or akinesia. No significant echo free space shall be demonstrated;
- c a 24-hour ambulatory ECG demonstrates no significant conduction disturbance, nor complex, nor sustained rhythm disturbance, nor evidence of myocardial ischaemia;
- d coronary angiography is carried out should there be any doubt about the result of non-invasive investigations (see Sub-Chapter 4 above);
- e six monthly follow-up by a cardiologist acceptable to the AMS with exercise ECG/scintigraphy/stress echocardiography and 2D Doppler echocardiography is carried out until complete resolution has been demonstrated;
- f recertification is restricted to multi-pilot operation (Class 1 'OML') for at least two years.

Review by a cardiologist acceptable to the AMS is required six-monthly, at first, with resting ECG and echocardiography. Supervision should continue for at least two years.

***This level of assessment also applies to Class 2 and Class 2 'OSL'.***

### 11.2 Constrictive pericarditis

Constrictive pericarditis is a rare form of pericarditis in Europe, often with insidious onset. Pericardectomy is normally disqualifying. Following surgical removal of the pericardium recertification, (Class 1 'OML'), may be considered provided the patient is in sinus rhythm and the requirement of 11.1 above can be fulfilled. Annual review by a cardiologist acceptable to the AMS is required.

## 12 CARDIOMYOPATHY

Cardiomyopathy is a disorder of heart muscle which is not secondary to hypertension, valvular or coronary disease or other identifiable cause. Its various forms are characterised by impairment of systolic and/or diastolic function. It may be subdivided into hypertrophic, dilated and obliterative/restrictive forms.

### 12.1 Dilated Cardiomyopathy

This form of cardiomyopathy is associated with dilatation of either the right and/or the left ventricle. It is characterised by reduced cardiac output with symptoms of fatigue and breathlessness. In the more severe forms, sudden cardiac death occurs in up to 50% of patients. It may be secondary to a viral illness, alcohol abuse, or be idiopathic or congenital, or be secondary to the conditions noted under myocarditis (paragraph 10) above. Complications include atrial and ventricular rhythm disturbances, cerebral embolism and sudden cardiac death. If limited to the right ventricle it may present as arrhythmogenic right ventricular dysplasia with associated risk of sudden cardiac death, especially in young adults. Established hypertension (the so-called compensated phase) is associated with concentric hypertrophy of the heart. Very similar appearances may be seen in aortic valve obstruction initially but late stage hypertensive heart disease is also commonly associated with dilatation of the heart. Before the availability of the angiotensin converting enzyme inhibitors (ACEI), in the idiopathic form up to two thirds of the patients died within two years of the diagnosis although a minority continued without evidence of further deterioration for a protracted period. Angiotensin converting enzyme inhibition has had a significant impact on the outcome and patients in whom this product is clinically indicated may be fit for aircrew duties.

Established dilated cardiomyopathy involving the left and/or the right ventricle is incompatible with flying status. The small percentage of patients who appear to make a complete recovery may be considered for multi-pilot operation (Class 1 'OML') not less than six months after recovery has been deemed to be complete, provided that:

- a A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no significant abnormality or evidence of myocardial ischaemia. Cardioactive medication (beta-blocking agents, vasodilators) ideally will have been withdrawn 48 hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an abnormality in the resting ECG;
- b echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction  $\geq$  0.50 without significant abnormality of wall motion such as dyskinesia, hypokinesia or akinesia;
- c coronary angiography is carried out should there be any doubt about the result of non-invasive investigations (see paragraph 4);
- d a 24-hour ambulatory ECG demonstrates no significant conduction disturbance, nor complex, nor sustained rhythm disturbance, nor evidence of myocardial ischaemia (see also paragraph 13);
- e six monthly follow-up by a cardiologist acceptable to the AMS with exercise ECG/scintigraphy/stress echocardiography, 2D Doppler echocardiography and 24-hour ambulatory ECG is carried out until complete stability has been demonstrated.

***This level of assessment also applies to Class 2. Applicants with minor degrees of left ventricular impairment, stable for at least two years, may be considered for Class 2 'OSL', without further investigation.***

## 12.2 Hypertrophic cardiomyopathy

Hypertrophic cardiomyopathy, septal hypertrophy of the interventricular septum and failure of diastolic function. A number of gene loci have been identified with associated abnormalities of contractile protein function. In general terms, in adulthood, but not in children or young adults, provided there is no family history of sudden cardiomyopathic death, vasomotor instability on exercise or occult or overt ventricular tachyarrhythmia, consideration can be given to certification. Increase in the left ventricular muscle mass may contribute to breathlessness due to loss of compliance but per se does not appear to be predictive of outcome. The resting ECG may be normal or more commonly demonstrates septal vectors, notably in the inferior leads, characterised by significant Q-waves with a widely discordant QRST angle. Septal vectors are also seen in the chest leads.

Difficulties may arise where there is minor isolated asymmetric hypertrophy (ASH) of the interventricular septum without other clinical, or diagnosis feature, on the resting ECG. If this is unassociated with other echocardiographic features of hypertrophic myopathy (i.e., reduction in left ventricular cavity size, systolic anterior motion of the mitral valve and evidence of diastolic dysfunction), a family history of sudden cardiac death, or evidence of autonomic nervous system dysfunction, the situation is likely to be benign but requires supervision by a cardiologist acceptable to the AMS and restriction to multi-pilot operation (Class 1 'OML').

Once the diagnosis of hypertrophic cardiomyopathy has been established, because of the excess potential risk of rhythm disturbance, syncope, cerebral embolism and sudden cardiac death, such individuals are unlikely to be fit for any form of certification. Applicants in whom features of hypertrophic cardiomyopathy are detected may be considered for multi-pilot operation (Class 1 'OML') provided that

- a A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no significant abnormality, particularly of pressor response to exercise. Cardioactive medication (beta-blocking agents, vasodilators) ideally will have been withdrawn 48 hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an abnormality in the resting ECG;
- b echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction  $\geq$  0.50 without significant abnormality of wall motion such as dyskinesia, hypokinesia or akinesia. The interventricular septal diameter shall be  $<$ 2.0 cm;
- c a coronary angiography is carried out should there be any doubt about the result of non-invasive investigations (see Sub-Chapter 4 above);
- d a 24-hour ambulatory ECG demonstrates no significant rhythm or conduction disturbance (see also paragraph 13). Evidence of non-sustained/sustained ventricular rhythm disturbance will disqualify.
- e follow-up by a cardiologist acceptable to the AMS with exercise ECG/scintigraphy, 2D Doppler echocardiography/stress echocardiography and 24-hour ambulatory ECG is carried out as appropriate;
- f recertification is restricted to multi-pilot operation (Class 1 'OML').

The presence of sustained or non-sustained ventricular tachycardia, unexplained dizziness or syncope, or significant increase in the intraventricular septum, (i.e.  $>$ 2.5 cms) disqualifies from all forms of certification. A family history of early sudden cardiac death needs to be very carefully reviewed.

***This level of assessment also applies to Class 2. Failure to meet these requirements in full may still be consistent with Class 2 'OSL'.***

### 12.3 Obliterative and restrictive cardiomyopathies

The obliterative cardiomyopathies may be associated with eosinophilic heart disease and have a poor prognosis due to an excess risk of pulmonary and systemic embolism. In the established condition, or in a patient in whom the presence of  $1 \times 10^9/L$  circulating degranulated neutrophils has been identified, certification to fly is not permissible.

The infiltrative (restrictive) cardiomyopathies such as amyloidosis, sarcoidosis and idiopathic fibrosis have a high incidence of arrhythmia, the possibility of sudden cardiac death, and may progress to heart failure. Sarcoidosis has a variable incidence across Europe and there is further variation within certain countries. Commonly the condition is picked up on routine chest x-ray, on account of co-existent erythema nodosum or fever and uveitis. Usually the bilateral hilar lymphadenopathy disappears within two years but systematic involvement occurs to an unknown extent and the condition may be diagnosed by scalene node biopsy. Myocardial biopsy may be indicated. Evaluation of the plasma angiotensin converting enzyme (ACE) levels will help establish active sarcoidosis if they are elevated. Evaluation of late potentials on the resting ECG may be considered. Some 5% of those with systemic involvement also have involvement of the heart. In such patients examination of the heart with MRI is required.

Myocardial involvement with sarcoidosis is associated with complete atrioventricular block and Morgagni-Adams-Stokes attacks. Ventricular rhythm disturbances are frequent and a significant number suffer sudden cardiac death. Others develop congestive cardiac failure and as a result sarcoidosis of the heart disqualifies from all classes of certification to fly.

Symptom-free individuals including those with sarcoidosis with radiographic signs only of sarcoidosis involving the hilar nodes may be considered for multi-pilot operation (Class 1 'OML') provided that:

- a A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no significant abnormality or evidence of myocardial ischaemia. Cardioactive medication (beta-blocking agents/vasodilators) ideally will have been withdrawn 48 hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an in the resting ECG;
- b echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction  $\geq 0.50$  without significant abnormality of wall motion such as dyskinesia, hypokinesia or akinesia;
- c coronary angiography is carried out should there be any doubt about the results of non-invasive investigations (see paragraph 4);
- d a 24-hour ambulatory ECG demonstrates no significant conduction disturbance, nor complex, nor sustained rhythm disturbance, nor evidence of myocardial;
- e six monthly follow-up by a cardiologist acceptable to the AMS with exercise ECG/scintigraphy/stress echocardiography, 2D Doppler echocardiography and 24-hour ambulatory ECG is carried out as appropriate;
- f recertification is restricted to multi-pilot operation (Class 1 'OML').

***This level of assessment also applies to Class 2. Any variation disqualifies from all classes of certification to fly.***

## 13 RHYTHM AND CONDUCTION DISTURBANCES

### 13.1 Rhythm disturbances

Rhythm disturbances give rise to problems with regard to certification particularly when paroxysmal. Some individuals when encountering their first such rhythm disturbance, be it atrial fibrillation, atrial flutter or supraventricular tachycardia (SVT) by whatever mechanism find the experience at least alarming. Such disturbances remain a potential causes of subtle incapacitation and retain a capacity for complete incapacitation by means of significant hypotension or embolic stroke. Some patients experiencing paroxysmal atrial fibrillation are unaware of the attacks, while others who develop chronic atrial fibrillation are equally unaware of any symptoms. These differences in the symptomatology observed by different individuals, or in the same individual in different attacks, need to be considered when attempting to maintain certification.

#### a *Atrial and ventricular premature beats*

Both atrial and ventricular premature beats are common findings in normal individuals. Atrial premature beats are usually harmless unless particularly frequent, in which case Holter monitoring should be carried out to seek the possibility of sino-atrial disease.

Ventricular premature beats are also usually harmless if infrequent and unifocal, and present in an otherwise normal heart. Evidence of multiformity, couplets and ventricular tachycardia if non-sustained (<5 seconds at a rate of >120 beats/min) may still be associated with a good prognosis in the normal heart but this is less certain. This has not been universally accepted and for this reason ventricular premature beats occurring in >2% of the total QRS count require further investigation, particularly if multifocal, or if couplets or salvos of ventricular tachycardia are present. Ventricular parasystole should be similarly considered. Certification to fly may be considered, provided that:

- i A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no significant abnormality (i.e. rhythm disturbance) or evidence of myocardial ischaemia. Cardioactive medication (beta-blocking agents/vasodilators) ideally will have been withdrawn 48 hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an abnormality in the resting ECG;
- ii echocardiography/radionuclide/contrast ventriculography demonstrates a right and left ventricular ejection fraction  $\geq$  0.50 without significant abnormality of wall motion such as dyskinesia, hypokinesia or akinesia;
- iii a 24-hour ambulatory ECG demonstrates no significant rhythm disturbance (the premature or aberrant atrial or ventricular beat count should be <2% of the total QRS count with no complex forms);
- iv cardioactive medication apart from beta-blocking agents, verapamil and digoxin shall not be permitted;
- v follow-up by a cardiologist acceptable to the AMS with exercise ECG/scintigraphy, 2D Doppler echocardiography and 24-hour ambulatory ECG is carried out as appropriate;
- vi recertification is restricted to multi-pilot operation (Class 1 'OML') unless the above requirements can be met in full.

***This level of assessment does not apply to Class 2. Class 2 'OSL' may be appropriate for private pilots failing to achieve the above criteria in full.***

#### b *Atrial fibrillation*

Atrial fibrillation may present as a single isolated event (for example, complicating a defined physical illness), in a paroxysmal form in which attacks may be separated sometimes by very long intervals of time, or it may be established. For the purposes of certification, paroxysmal atrial fibrillation will be defined as more than one attack with no time limit. Any single episode of this disturbance can be associated with problems such as valvular or hypertensive heart disease, myocardial ischaemia, or primary myocardial abnormalities. The

possibility of alcohol abuse and thyrotoxicosis also need to be considered. An airman with any such concomitant diagnosis is likely to be unfit for any form of certification to fly. 'Lone' atrial fibrillation may be present when there is no other demonstrable cause or other cardiac abnormality. In no case shall a Class 1 certificate be issued to a pilot with paroxysmal or established atrial fibrillation once he/she has reached the age of 60 years due to the excess risk of thromboembolic stroke in the absence of treatment with warfarin.

Generally the use of medication in aeromedical certification is not advised. One exception apart from hypertension may be atrial fibrillation when attempting to suppress attacks (i.e. of paroxysmal disturbance of rhythm) or to help control the rate when the rhythm disturbance is established. Permissible medication at present includes sotalol, other beta-blocking agents, verapamil, or digitalis products in adequate dose. The Class 1 agents (i.e. quinidine, flecainide, propafenone) are not permitted, nor are Class 3 agents (i.e. amiodarone, disopyramide) on account of side effects. Cardiological supervision acceptable to the AMS is required as well as demonstration of freedom from unwanted effects. The latter is usually best carried out in a flight simulator.

Assuming no other disqualifying conditions are present, an airman may be considered for restricted certification (Class 1 'OML'), provided that:

- i The resting ECG is within normal limits. If atrial fibrillation is present, the rate shall be controlled (i.e. resting rate <90 beats/min, on exercise >220 beats/min) and any QRST abnormality should be attributable to medication or heart rate only;
- ii a symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no significant abnormality (i.e. inappropriate rate) or evidence of myocardial ischaemia. Cardioactive medication (beta-blocking agents/vasodilators) need not be discontinued. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an abnormality in the resting ECG;
- iii echocardiography/radionuclide/contrast ventriculography demonstrates right and left ventricular ejection fractions  $\geq$  0.50 and the 2D Doppler echocardiogram is within normal limits. The left atrial internal diameter shall not exceed 4.5 cm;
- iv 48 hours of ambulatory ECG on 3 separate occasions separated by an interval of 4 weeks each should demonstrate the absence of atrial fibrillation (having presented as a single attack, or in paroxysmal form) and of significant pauses (>2.5 sec) during the daytime. In the presence of established atrial fibrillation, the shortest RR interval shall not exceed 300 ms and the longest 3.5 sec. The longest pause on recapture of sinus rhythm shall not exceed 2.5 sec. Ventricular arrhythmia should not exceed an aberrant beat count >2% of the total QRS count with no complex forms. If atrial fibrillation is provoked by exercise, this should be managed as the paroxysmal form;
- v coronary angiography is carried out should there be any doubt about the result of non-invasive investigations (see paragraph 4);
- vi following a single attack of atrial fibrillation with a defined cause, an applicant who has satisfactorily completed the above investigations may be certificated fit Class 1 'OML' subject to a review every 6 months by a cardiologist acceptable to the AMS. Restoration of a full Class 1 certificate may be considered after an interval of not less than two years provided that there are no further symptoms suggestive of atrial fibrillation, nor of a recorded episode;
- vii following a second or further attack of paroxysmal atrial fibrillation, and following satisfactory completion of the above, the airman may be considered for certification provided he/she is under cardiological supervision acceptable to the AMS and receiving appropriate medication, if indicated (see above). If the attacks are completely suppressed, restricted Class 1 certification may be considered. Repeated 24-hour ambulatory ECG should be carried out initially and no less frequently subsequently than twice a year. If suppression of the attacks is incomplete, or if/when

atrial fibrillation becomes established, an AMS decision based on individual assessment of symptoms during an attack, rate experience and other relevant data shall be required;

- viii provided the above requirements can be satisfied in full, established atrial fibrillation is consistent with Class 1 'OML' certification subject to review every 6 months by a cardiologist acceptable to the AMS with 24-hour ambulatory ECG and echocardiography.

Other paroxysmal disturbances such as atrial flutter and paroxysmal atrial tachycardia are usually at a rate which, unsuppressed, give rise to significant symptoms and are incompatible with any form of certification to fly. Electrophysiologically demonstrated ablation of a flutter circuit may be an exception no sooner than 6 months following intervention.

c *Sinus node arrest and sinoatrial block*

Sinoatrial disorders are infrequent in flight crew but similar disturbances are sometimes seen in those in good athletic training with high vagal tone.

Pauses >2.5 seconds are probably abnormal, although may be provoked by vagal effects including exaggerated sinus arrhythmia. Sinus node dysfunction usually progresses slowly and the outlook is good over many years. Evidence of early sinoatrial node dysfunction may be inferred by a reduced heart rate response to atropine or exercise. Sinus node recovery time on electrophysiological testing is prolonged in about half of those investigated. Salvoes of fast atrial rhythm disturbance may also be present.

It should be assumed that a subject in whom the diagnosis of sinoatrial disease has been made will eventually become symptomatic. Symptomatic pauses require endocardial pace-making. Those with asymptomatic pauses brought to light by routine resting ECG may be considered for certification, provided that:

- i A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no significant abnormality or evidence of myocardial ischaemia. Cardioactive medication (beta-blocking agents/vasodilators) ideally will have been withdrawn 48 hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an abnormality in the resting ECG;
- ii echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction  $\geq$  0.50 without significant abnormality of wall motion such as dyskinesia, hypokinesia and akinesia.
- iii a 24-hour ambulatory ECG demonstrates no significant conduction disturbance, nor complex, nor sustained rhythm disturbance, nor evidence of myocardial ischaemia (i.e. pauses >2.5 s);
- iv electrophysiological study, if carried out, shall show a normal sinus node recovery time and normal conduction velocities;
- v follow-up by a cardiologist acceptable to the AMS with exercise ECG/scintigraphy/stress echocardiography, 2D Doppler echocardiography and 24-hour ambulatory ECG is carried out as appropriate;
- vi recertification is restricted to multi-pilot operation (Class 1 'OML').

***This level of assessment also applies to Class 2. Applicants who are free of symptoms but do not satisfy the above requirements may be considered for Class 2 'OSL'***

The presence of symptoms is disqualifying.

d *Paroxysmal narrow complex tachycardias (Atrioventricular node reentrant tachycardia and atrioventricular reentrant tachycardia (pre-excitation))*

The most common causes of 'paroxysmal supraventricular tachycardia' include atrioventricular nodal reentry (AVNRT) – 50% of all, and atrioventricular reentry or 'pre-excitation' – 30% of all. Less common are other forms of narrow complex tachycardia including sino-atrial nodal reentry, atrial tachycardia and other incessant supraventricular rhythms. All suffer the disadvantage that the fast heart rates involved are at best distracting and at worst potentially incapacitating. Radiofrequency ablation is being increasingly used for ablation of identifiable bypass pathways (i.e. the Kent bundle) and it may be consistent with certification. Rhythm disturbances involving nodal reentry may be less satisfactorily dealt with in this manner.

e *Ventricular pre-excitation*

A number of different examples of ventricular pre-excitation due to the presence of intra- or extranodal pathways have been described. These include the Wolff-Parkinson-White pattern (Kent bundle), Ganong-Levine (James bundle) and paraspecific Mahaim forms. Such electrocardiographic abnormalities are seen in approximately 0.25% of asymptomatic individuals with a risk of about 2% of significant tachyarrhythmia.

If atrioventricular reentrant tachycardia (AVRT) or atrioventricular nodal reentrant tachycardia (AVNRT) is to develop this commonly occurs in the first two or three decades of life and less commonly as a first event thereafter. Atrioventricular reentrant tachycardias can both give rise to hypotension and syncope, particularly if atrial fibrillation develops and conduction occurs at a rapid rate via the accessory pathway. Subjects in whom a delta wave is intermittently present due to intermittent refractoriness of the bypass pathway are likely to be 'safe' and have a longer effective refractory (ERF) period of the bypass tract.

The discovery of a pattern of pre-excitation on the resting ECG may be consistent with certification to fly provided that:

- i A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no significant abnormality or evidence of myocardial ischaemia. Cardioactive medication (beta-blocking agents/vasodilators) ideally will have been withdrawn 48 hours beforehand. Scintigraphy/stress echocardiography may be helpful in the presence of a delta wave disturbance in the resting ECG due to the likelihood of significant repolarisation changes in the exercise ECG;
- ii echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction  $\geq$  0.50 without significant abnormality of wall motion such as dyskinesia, hypokinesia or akinesia;
- iii there is no history of ongoing paroxysmal rhythm disturbance;
- iv a 24-hour ambulatory ECG demonstrates no significant rhythm or conduction disturbance nor evidence of myocardial ischaemia;
- v an electrophysiological study demonstrates an effective refractory period  $>$ 300 ms in an accessory pathway, if present unless a 24-hour ambulatory ECG demonstrates disappearance of the delta wave from time to time;
- vi follow-up by a cardiologist acceptable to the AMS with exercise ECG/scintigraphy, 2D Doppler echocardiography and 24-hour ambulatory ECG, if necessary, is carried out as appropriate;
- vii certification is restricted to multi-pilot operation (Class 1 'OML').

Ablation of an accessory pathway or a slow conducting pathway in nodal reentrant tachycardia, or of an atrial flutter circuit when demonstrated electrophysiologically to have been complete may be consistent with restricted certification (Class 1 'OML') no sooner than 6 months following

intervention. Unrestricted certification may be permitted no sooner than 24 months provided there is no order disqualifying or associated abnormality.

***This level of assessment also applies to Class 2. Applicants not completely fulfilling the above who nevertheless have no history of a sustained tachycardia may be considered for Class 2 'OSL'.***

The presence of atrioventricular reentrant tachycardia or paroxysmal atrial fibrillation in the presence of an accessory pathway shall disqualify from all classes of certification to fly.

### 13.2 Conduction disturbances

#### a Atrioventricular block

First degree heart block is not uncommon in fit young men and the PR interval may exceed 0.20 secs not uncommonly in the presence of a bradycardia. In the absence of a bundle branch disturbance the situation is most often benign. Occasionally very long PR intervals are seen, up to 0.4 seconds which shorten on exercise and with atropine and are likely to represent an exaggerated vagal phenomenon. Subjects who demonstrate shortening of the PR-interval to <200 ms with exercise/atropine, may be considered for Class 1 certification.

The co-existent presence of a bundle branch disturbance suggests distal conducting tissue disease, particularly if right or left bundle branch block is present with left or right axis deviation. This requires evaluation with 24-hour ambulatory monitoring and an electrophysiological study (see paragraphs 13.2 b and c).

Asymptomatic Mobitz Type I (Wenkebach) atrioventricular block occurs in normal individuals during sleep but the periodicity should be short. The presence of a narrow QRS complex usually indicates that the block is junctional and it is sometimes associated with prolongation of the PR interval. This may not be the case in older age groups and at least two studies have suggested that narrow complex Mobitz Type I block may progress to complete atrioventricular block in young people. Certification to fly may be considered, provided that

- i A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no significant abnormality or evidence of myocardial ischaemia. Cardioactive medication (i.e. beta-blocking agents/vasodilators) ideally will have been withdrawn 48 hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an abnormality in the resting ECG;
- ii echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction ? 0.50 without significant abnormality of wall motion such as dyskinesia, hypokinesia or akinesia;
- iii a 24-hour ambulatory ECG demonstrates no significant rhythm (see paragraph 14.1 b) or conduction disturbance, nor evidence of myocardial ischaemia (i.e. other than short periodicity Mobitz type 1 AV block at night);
- iv electrophysiological study, if carried out, shows normal conduction velocities within the normal range;
- v annual review by a cardiologist acceptable to the AMS with exercise ECG/ scintigraphy, 2D Doppler echocardiography and 24-hour ambulatory ECG monitoring is carried out as appropriate;
- vi recertification is restricted to multi-pilot operation (Class 1 'OML') or refused unless the above requirements can be met in full.

***This level of assessment also applies to Class 2 and Class 2 'OSL'.***

Evidence of distal conducting tissue disease on electrophysiological study disqualifies from all classes of certification to fly.

The presence of Mobitz Type II, 2:1 and 3:1 atrioventricular block is incompatible with any class of certification to fly.

Complete congenital atrioventricular block is a rare condition which may become symptomatic during early adult life. As a result it is not consistent with any class of certification to fly.

**b** *Right bundle branch block*

Incomplete right bundle branch block is seen in 2–3% of routine flight crew electrocardiograms and appears to carry a normal prognosis in asymptomatic subjects. No special requirements are needed.

Complete right bundle branch block has a prevalence of about 0.2% in flight crew. When isolated, established and unassociated with other abnormality of the myocardium or coronary circulation, there appears to be no significant risk of development of further degrees of block or of syncope. Recently acquired right bundle branch block usually also has a benign prognosis provided significant coronary artery disease is not present.

On first presentation of complete right bundle branch block certification to fly may be considered, provided that:

- i A symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no significant abnormality or evidence of myocardial ischaemia. Cardioactive medication (i.e beta-blocking agents/vasodilators) ideally will have been withdrawn 48 hours beforehand. Scintigraphy/stress echocardiography may be helpful for future reference and/or in the presence of an abnormality in the resting ECG;
- ii echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction  $\geq$  0.50 without significant abnormality of wall motion such as dyskinesia, hypokinesia or akinesia;
- iii coronary angiography is carried out should there be any doubt about the result of non-invasive investigations (see paragraph 4 above);
- iv the co-existent presence of first degree heart block and anterior or posterior hemiblock is evaluated by an electrophysiological study.
- v a 24-hour ambulatory ECG demonstrates no significant rhythm disturbance or higher degree of conduction disturbance;
- vi follow-up by a cardiologist acceptable to the AMS with exercise ECG/scintigraphy, 2D Doppler echocardiography and 24-hour ambulatory ECG is carried out as appropriate;
- vii recertification is restricted to multi-pilot operation (Class 1 'OML') for at least one year when stable. Established complete right bundle branch block may be considered for unrestricted Class 1 subject to satisfactory completion of the above.

***This level of assessment also applies to Class 2 and Class 2 'OSL'.***

**c** *Left bundle branch block*

Left bundle branch block is an uncommon problem in otherwise healthy flight crew. In at least one quarter it will be due to co-existent coronary artery disease and this needs to be excluded at least by exercise scintigraphy/stress echocardiography and/or by coronary angiography on first appearance. In the recently acquired form, the risk of sudden cardiac death in patients above age 45 years is ten times that of the peer group but this has not been seen below age 45 years. The mortality risk ratio in patients with established complete

left bundle branch block appears to be about 1-33. Rate related left bundle branch block should be treated in the same manner. Certification to fly may be considered provided that:

- i A symptom-limited exercise scintigraphy/stress echocardiography to Bruce stage IV, or equivalent, shows no significant abnormality or evidence of myocardial ischaemia. Cardioactive medication (beta-blocking agents/vasodilators) ideally will have been withdrawn 48 hours beforehand;
- ii coronary angiography shows no evidence of significant coronary artery disease (see paragraph 4);
- iii echocardiography/radionuclide/contrast ventriculography demonstrates a left ventricular ejection fraction  $\geq$  0.50 without significant abnormality of wall motion such as dyskinesia, hypokinesia or akinesia;
- iv a 24-hour ambulatory ECG demonstrates no significant rhythm, or higher degree of conduction disturbance;
- v an electrophysiological study shows evidence of an HV interval  $<$ 70ms;
- vi follow-up by a cardiologist acceptable to the AMS with exercise ECG/scintigraphy/stress echocardiography, 2D Doppler echocardiography and 24-hour ambulatory ECG is carried out as appropriate;
- vii recertification is restricted to multi-pilot operation (Class 1 'OML') for at least 3 years. Re-evaluation at that time, if satisfactory, may lead to removal of restriction.

***This level of assessment also applies to Class 2. Applicants not fulfil all the above requirements may be considered for Class 2 'OSL' certification.***

d *Left anterior and left posterior hemiblock*

Left anterior hemiblock has a 1–2% prevalence in normal individuals. When isolated and stable it appears to carry no appreciable risk of progression to higher degrees of block. Recently acquired left anterior hemiblock raises the possibility of myocardial ischaemia and requires at least exercise ECG to Bruce stage IV. Stable incomplete left bundle branch aberration (complex  $<$  120ms) in the absence of any other abnormality appears to carry no greater risk than the pre-existing left anterior hemiblock. If recently required the protocol applied to the left bundle branch is required. Occasional progression to complete left bundle branch block may be seen (see paragraph 13.2 c).

Left posterior hemiblock has a prevalence in healthy flight crew of 0.1%. There are no data on risk of progression and in an otherwise asymptomatic individual no special action is needed. Recently acquired left posterior hemiblock justifies exercise ECG and review by a cardiologist acceptable to the AMS.

**[14] CONGENITAL HEART DISEASE**

Most forms of congenital heart disease are incompatible with flying status and only those that are of sufficiently low risk before or after corrective surgery are detailed here. All require regular cardiological review and appropriate, usually non-invasive investigation.

**[14.1] Atrial septal defect**

Atrial septal defects account for over a quarter of all individuals with congenital heart disease. An ostium primum defect carries a risk of progressive mitral regurgitation and conduction disorder. Restricted certification (Class 1 'OML') to fly may be granted provided mitral regurgitation is demonstrated by 2D Doppler echocardiography to be minimal or absent and 24-hour ambulatory ECG shows no significant rhythm or conduction disturbance. This applies both before and after

surgery. Indefinite review by a cardiologist acceptable to the AMS is required in view of the risk of late arrhythmia.

- a Ostium primum defects are consistent with Class 1 'OML' if small, i.e., the pulmonary systemic flow ratio  $<1.5:1$ , or following surgical correction. The pulmonary pressures should be normal.
- b An uncorrected small secundum defect with no other abnormality is consistent with Class 1 status provided the right ventricular pressures are normal. The pulmonary systemic flow ratio should be  $<1.5:1$ . In view of the risk of late arrhythmias, certification following surgical correction may need to be restricted to multi-pilot duties (Class 1 'OML'). Pulmonary pressures should be normal. Indefinite review by a cardiologist acceptable to the AMS is required at intervals, before and after operative correction, in view of the risk of late arrhythmia.

#### 14.2 Sinus venosus defects

Subjects with sinus venosus defects may be considered for Class 1 'OML' if the defect is too small to require surgical repair, 24-hour ambulatory ECG does not reveal rhythm or conduction disturbances more important than an aberrant beat count  $<2\%$  of the total QRS count, with no complex forms, and no significant conduction disturbance. Following surgery the increased risk of arrhythmia precludes certification (Class 1 'OML') except where repeated ambulatory monitoring has shown there to be no significant rhythm disturbance. Annual review by a cardiologist acceptable to the AMS with 2D Doppler echocardiography and 24-hour ambulatory ECG is required.

#### 14.3 Ventricular septal defect

Ventricular septal defect accounts for almost a third of all congenital heart disease. Subjects who have a normal cardiac configuration on chest x-ray, a pulmonary/systemic flow ratio  $<1.5$  and no evidence of pulmonary hypertension are fit for unrestricted certification (Class 1). There is a small risk of arrhythmia following surgical closure although the risk of endocarditis is largely removed. Occasional cardiological review is required.

#### 14.4 Pulmonary stenosis

Isolated pulmonary valvular stenosis accounts for one tenth of individuals with congenital heart disease. Subvalvular (infundibular) and supra-valvular stenoses are much rarer. Subvalvular stenoses in the anatomically normal heart with an intact ventricular septum may occur in the form of a fibromuscular ring or as concentric thickening of the myocardium. The valve also may be involved and stenosed. Supra-valvular stenosis may affect the pulmonary trunk, the pulmonary arteries or there may be multiple stenoses. Supra-valvular stenosis is likely to disqualify but corrected infundibular stenosis may be permissible. Provided the pressure difference is  $>30$ mmHg peak to peak and the situation is stable, then the outlook is good. A minor degree of pulmonary stenosis is consistent with unrestricted certification (Class 1) provided there is no evidence of right ventricular hypertrophy on 2D Doppler echocardiography. With a drop  $>20$  mmHg but  $<30$  mmHg Class 1 'OML' status may be granted with annual review by a cardiologist acceptable to the AMS to confirm the stability of the situation. 2D Doppler echocardiographic assessment is acceptable if the signals are good.

#### 14.5 Patent ductus arteriosus

Patent ductus arteriosus is a common anomaly representing perhaps 10% of all congenital abnormalities of the heart. It is often associated with other anomalies. This anomaly may be associated with a bicuspid aortic valve. Following closure no special risks appear to accrue provided the shunt was not large and pulmonary hypertension is not present. A closed defect is consistent with Class 1 certification to fly while a small unclosed defect requires a Class 1 'OML' limitation.

#### 14.6 Coarctation of the aorta

Late correction (i.e., >age 12 years) of a coarctation of the aorta appears to be associated with a higher risk of sudden cardiac death and stroke. If the condition is corrected <age 12 years and the subject is normotensive both at rest and on exercise, then Class 1 certification to fly may be appropriate. Late surgical correction requires Class 1 'OML' with indefinite supervision of the blood pressure. 30% of patients with coarctation also have a bicuspid aortic valve. Late surgical correction is also associated with an increased risk of dissection of the aorta and ruptured berry aneurysm (see paragraph 8.2).

***These levels of assessment also apply to Class 2 and Class 2 'OSL'.***

#### 14.7 QT Prolongation

QT prolongation is occasionally detected in aircrew although it is probably more commonly missed. Congenital forms associated with deafness may be transmitted as an autosomal recessive characteristic (Jervell, Lange Neilsen) and in the absence of deafness as an autosomal dominant characteristic (Romano Ward). Often the QT interval is significantly prolonged (>550ms) and the T waves bizarre. There is a risk of ventricular tachycardia and sudden cardiac death. When identified, these syndromes are not consistent with any form of certification to fly.

Less obvious changes in the QT interval in an asymptomatic individual (arbitrarily >440ms) expressed at the interval itself, or as its derivative the Qtc (the correction applied by Bazett by dividing the QT interval in ms by the square root of the RR interval expressed in seconds) are occasionally encountered in the absence of medication which might provoke such features. Under these circumstances, a full evaluation with particular attention to family history, structural abnormality of the heart and electrophysiological characteristics of the myocardium is indicated.

### 15 IMPLANTABLE DEVICES & AVIATION

#### 15.1 Endocardial pacemaker

Permanent endocardial pacemakers are rarely required in personnel of flight crew age. A failure rate between 0.12–1.44% per annum is to be expected which is within the overall permitted annual target event rate. The possibility of electrical interference has also been investigated in aircraft, although mainly in unipolar systems. Applicants may be considered for certification for multi-pilot operation (Class 1 'OML') three months following an insertion, provided that:

- a there is no other disqualifying condition;
- b a bipolar lead system has been used;
- c the applicant is not pacemaker dependent;
- d a symptom-limited exercise ECG to Bruce stage IV, or equivalent, shows no abnormality or evidence of myocardial ischaemia. Scintigraphy/stress echocardiography may be helpful in the presence of a conduction disturbance/paced complexes in the resting ECG;
- e 2D Doppler echocardiography shows no abnormality;
- f a 24-hour ambulatory ECG shall demonstrate no tendency to symptomatic or asymptomatic tachyarrhythmia;
- g six monthly follow up by a cardiologist acceptable to the AMS with a pace-maker check and 24-hour ambulatory ECG is carried out as appropriate;
- h recertification is restricted to multi-pilot operation (Class 1 'OML').

***This level of assessment also applies to Class 2. Applicants failing to fulfil all of the above may be considered for Class 2 'OSL'.***

Anti-tachycardia pace-makers and automatic implantable defibrillating systems are not permitted.

[Amdt.1, 01.12.00]

INTENTIONALLY LEFT BLANK

INTENTIONALLY LEFT BLANK