CHAPTER 3 – CARDIOLOGY

(Cardiac Conditions)

ACKNOWLEDGEMENTS

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3.1.1 The Purposes of Medical Assessment of Cardiac Conditions

[DME,AMA]

(a) General

Apart from the more obvious question of whether an individual has a disability affecting cardiovascular function (which may be worsened by the aviation environment), the CAA emphasises two other distinct functions of the medical assessment of cardiological fitness. These are:

(i) to ***stratify the fit pilot population***, so that the group identified ***early*** as more likely to develop coronary artery disease (**CAD**) can be given ***preventive advice***, and also put under closer ***surveillance***;

(ii) to ***identify individuals who have exceeded CAA's limit for acceptable risk of sudden incapacitation***, and refer these to the PMO for special assessment (to be granted exemption with suitable restrictions; or refused exemption).

This implies the task of ***predicting the risk of sudden incapacitation*** in a single individual who has been drawn to the attention of the medical examiner as the result of some variation on routine medical screening. This ***risk assessment*** process is an essential part of a CAA medical assessment but is not generally familiar to clinicians. It is discussed in 3.1.2.

(b) Coronary artery disease

Next to acute gastrointestinal disturbance (which unfortunately is not predictable) coronary artery disease is the most common disease entity causing sudden pilot incapacitation. Some cases will be asymptomatic, others will present with a myocardial infarction or other acute coronary syndrome, but ***in a substantial proportion of individuals (15% or more), the first manifestation of coronary disease will be sudden death***. While we know a great deal about the epidemiology of CAD and incidence of sudden death due to this in large populations, we still have difficulty in predicting the risks for the occurrence of a sudden incapacitating event due to myocardial ischaemia in a specific individual.

3.1.2 The Risk Assessment Process

[AMA]

(a) In Volume 1, section 3.7, an introduction to Criteria for Acceptable Risk of Pilot Impairment or Incapacitation was presented. Although this approach involves very general principles which are the field of the aviation medicine specialist, it has special relevance to cardiac incapacitation and so is worth summarising here.

(b) These principles were covered well in an early paper by Chapman "The Consequences of In-Flight Incapacitation in Civil Aviation" (Aviation, Space & Environ Med June 1984). As he put it, the pilot should be considered to be little different from a component of an aircraft. Airworthiness requirements set acceptable limits for failure rates of aircraft components. These vary a little from one state to another, but there is increasing agreement. One accepted limit is for failures likely to lead inevitably to an *accident* – for airline pilots this is set at 1 per 10^9 flying hours (or 10^{-9}). Another is for failures which reduce the ability of crew to cope with adverse operating conditions (and would produce an *"aviation safety incident"*). This is set at between 10^{-5} and 10^{-8} flying hours. For airline flying, it was assumed that the annual exposure to risk was 600 hours flying per pilot, and ***it is now generally agreed that taking this into account, an annual risk of 1% for a cardiac event (at any time of day or night) is equivalent to this 10^{-9} acceptable level of risk.*** A 1% level of risk for a cardiac event is reached by the general population in the age range 60-65 years, which until recently coincided with the mandatory retirement age for airline pilots (though human rights issues have been altering this in the USA and elsewhere).

(c) Chapman also made the point that it is inappropriate to expect cardiologists to make the operational aviation decision of whether a pilot is fit to fly safely. It is more appropriate to ask the cardiologist to estimate in each case the level of risk for sudden incapacitation. Hence the "1%" rule which bridges the gap between the discipline of cardiology (on the one hand) and of aviation risk assessment (on the other). Some will argue that whilst this all makes sense, it may be asking too much to presume that a cardiologist can place a figure on the "level of risk". Certainly you can ask whether the person is at ***high***, ***medium***, or ***low risk*** of sudden incapacity (or at no greater risk than the age group in question) and perhaps get a helpful answer. Nevertheless, *since individual perceptions vary on what is meant by these descriptive terms (as evidenced by the use of similar terms in the tables of Appendix B),* it is essential for the cardiologist to bear in mind CAA's definition of the bands of risk (see next page, under the heading "*Conclusion*").

(d) Chapman found that for cardiac incapacitation the level of safety being achieved by airlines via the multicrew system (which adds a further safety factor of 10^2 by virtue of having a spare pilot) actually seemed to exceed the 10^{-9} criterion by a factor of up to 10. This led to the possibility of relaxing medical standards for cardiac incapacitation in the airline situation (including accepting a later retirement age). This also gives CAA more latitude for granting special issuances to ATPL holders, using restriction #131.

(e) On the other hand, commercial pilots may only be able to achieve a level of risk of 10^{-7} for in-flight cardiac incapacitation if they have a 1% risk of a cardiac event and are not restricted to multicrew flying. The question is muddied further by the sometimes very heavy hours flown by commercial pilots. Decisions on what is an acceptable risk in this situation are still evolving, but this level at present is probably acceptable. Accident rates are higher in general aviation than in scheduled airlines for other reasons (notably mechanical failures, and decision-making errors), and it would be anomalous to insist on a lower incapacitation rate in solo commercial pilots while higher failure rates are tolerated in other aircraft systems. Similar arguments apply to private pilots, who also bear a lower degree of responsibility since they do not fly "for hire or reward".

(f) A review of the "1% rule" for cardiovascular (CVS) risk was commissioned by the Minister of Transport and carried out by Bruce Corkill and Dr Simon Janvrin in 2001. In keeping with their recommendations, the CAA advises:

- CVS risk assessment should be carried out in cases where the applicant for the certificate is below 40 years of age, where risk factors such as strong family history, familial hyperlipidaemia, or other metabolic disorders (diabetes, morbid obesity etc) exist. It should be carried out in all cases where the applicant is over the age of 40.

- The AMA may use either the National Heart Foundation tables, the CASA (Civil Aviation Safety Authority Australia) tables, or the Flight Fit Program. The CAA encourages the use of the Flight Fit software.

- The CAA has accepted a 1% per annum risk (or 5% per 5 years) as the boundary between good risk and borderline risk, and 2% per annum risk (or 10% per 5 years) as the boundary between borderline risk and unacceptable risk.

- The AMA should use medical judgment for risks in the "borderline" range (1% or more pa), provided no identified cardiac condition exists. The AMA should provide change of lifestyle advice and put in place a surveillance program, together with the appropriate endorsement of the medical certificate, to monitor the risk.

In cases where the CVS risk estimate falls in the "unacceptable" range (2% or more pa), the AMA should refer the applicant for a stress ECG and a cardiologist consultation. A 60-day certificate may be issued in the interim.

3.2 Examinations and Tests

[DME]

3.2.1 History Taking

(a) Routine History Taking:

The following questions in part 17 of the CAA Form /201 are directly relevant to the cardiovascular system:

(17a) ***"Dizziness or fainting spell"***;

(17c) ***"Abnormal shortness of breath"***;

(17d) ***"Heart or vascular problem; chest pains or discomfort; Rheumatic Fever; high or low blood pressure"***;

and there are also more general inquiries that may reveal a problem related to the cardiovascular system (17k – ***rejections involving employment or insurance***, 17l – "***Admission to hospital; other illness, disability or surgery***" and 18 – 28 regarding ***other health visits; medication; alcohol & smoking; family history***). In addition, some **cardiovascular risk factors** are considered in questions 22 to 27 of the form, and on page 2 of recent reprints of the form, item 5(b) solicits a copy of any **blood lipid screen** done. Any positive response must be followed up with the detailed history set out below in Section (b). This information will aid risk assessment.

In a young candidate who discloses no symptoms that could have a cardiac cause, who has no undue elevation of cardiovascular risk factors, and who is physically active, no additional questions are necessary.

Any older candidate (i.e. over 40 years of age), or any candidate who has **positive risk factors for ischaemic heart disease**, should be questioned further about physical capacity and if there is any suspicion of limitation, a detailed history should be taken as described below.

(b) Detailed History of Cardiovascular Function and Dysfunction:

Cardiac function:

Occupation, and the level of activity required for work.

Sports and hobbies and the level of activity required.

Usual level of physical activity, and at what level activity is limited by breathlessness or chest tightness.

Cardiac dysfunction:

Chest pain: Nature, location, relationship to exertion, meals, stress or lying down.

Abnormal chest sensations: Tightness or discomfort.

Dyspnoea: Relationship to exertion, stress or lying down.

Palpitations: When, how often, duration, associated symptoms such as faintness, visual dimming, or chest pain, and any precipitants recognised.

Ankle swelling: Severity and time of day swelling present.

Syncope: When, how often, associated symptoms such as palpitations, visual dimming, or chest pain, and any precipitants recognised.

Claudication: History of effort-related intermittent leg pain suggesting muscle ischaemia.

3.2.2 Clinical Examination

(a) The following must be included:

Pulse: Rate, rhythm, character, and volume.

Peripheral Circulation: Coldness or blueness of the extremities. In any candidate over 40 or who smokes, peripheral pulses should be checked.

Blood Pressure: Can generally be measured seated, but if doubts arise, should be measured once lying and once standing, as described below.

Carotid Arteries: Should be checked for bruits over the age of 40.

Neck Veins: Check for elevation of venous pressure, and look for unusual pulsation.

Chest Wall: Look for deformities and for scars of previous surgery.

Apex Beat: Should not be abnormally displaced.

Auscultation: In mitral, tricuspid, aortic and pulmonary areas, listen for abnormal heart sounds and murmurs. If there is any possibly significant abnormality, a cardiologist's opinion must be obtained before issuing a CAA Medical Certificate. If the candidate was aware that a variation had previously been noted, this may take the form of obtaining a report from a physician who had evaluated the variation previously. It is not sufficient to take the patient's word that the murmur is not significant.

Electrocardiography: As described below, at examinations where this is expected routinely under Part 67, or where indicated by the findings on clinical examination.

Percentage Body Fat: The % Body Fat can be indirectly estimated from the Body Mass Index (see 3.2.2c below). Where the % Body Fat derived from the BMI is less than 20%, the inaccuracies associated with this method of estimation are unimportant. However, when the BMI-derived % Body Fat exceeds 20%, the estimation of percentage body fat must be checked using skin-fold thickness measurements. If you do not have the facilities for this, alternative arrangements for measurement must be made.

Cardiac Risk Factor Evaluation: See Section 3.3.3. Without legislation to make limited blood lipid screening compulsory, ***it is considered good practice to obtain a single initial blood lipid estimation in any pilot before age 40 years***. Examinees who have reached or exceeded this age without having had such an initial lipid screen, should be urged to have this done at the earliest possible CAA medical examination, and this is ***required*** in anyone whose risk is estimated (by other means, see 3.1.2) to be ***borderline***. According to the results of this and other risk factor evaluation, blood lipid profiles may be necessary at further intervals. In some cases CAA may require an exercise study to be done.

(b) Measurement of Blood Pressure:

This is detailed in section 3.4. The maximum permissible blood pressure will depend on the age of the candidate, and the elevation of cardiac risk factors. Further evaluation and completion of a ***CAA24067/214 Blood Pressure Examination Report form*** will be required for any candidate in whom the mean value of all lying blood pressures recorded exceeds the following maximum limits:

less than 40 years	145/90
40 – 49 years	155/95
more than 50 years	160/100

For further details, see Section 3.4 for the procedures to be adopted in the evaluation of hypertensive candidates.

(c) Body Mass Index:

The estimation of this is carried out using the tables below. The subject is weighed, with any deduction for clothes. The net weight (unclothed) is expressed in grams. The height is recorded to the nearest cm (without shoes).

$$\text{Body Mass Index (BMI)} = \frac{\text{Weight in grams x 10}}{\text{Height in cm}^2}$$

(example) Weight = 78.2 kg = 78,200 gm; Height = 179 cm

$$\text{BMI} = \frac{78{,}200 \times 10}{179^2} = \frac{782{,}000}{32041} = \mathbf{24.4}$$

Table I gives the squares of heights (cm) for easy reference.

Table II gives percentage variation from the ideal weight calculated from the BMI for people of medium build. For people of heavy build 5 percent is deducted and for people of light build five percent is added.

Table I

Height, in cm	cm^2	Height, in cm	cm^2	Height, in cm	cm^2	Height, in cm	cm^2
130	16900	147	21609	164	26896	180	32400
131	17161	148	21904	165	27225	181	32761
132	17424	149	22201	166	27556	182	33124
133	17689	150	22500	167	27889	183	33489
134	17956	151	22801	168	28224	184	33856
135	18225	152	23104	169	28561	185	34225
136	18496	153	23409	170	28900	186	34596
137	18767	154	23716	171	29241	187	34969
138	19044	155	24025	172	29584	188	35344
139	19321	156	24336	173	29929	189	35721
140	19600	157	24649	174	30276	190	36100
141	19881	158	24964	175	30625	191	36481
142	20164	159	25281	176	30976	192	36864
143	20449	160	25600	177	31329	193	37249
144	20736	161	25921	178	31684	194	37636
145	21025	162	26244	179	32041	195	38025
146	21316	163	26569				

Table II: Percentage variation in weight from ideal weight

(For Medium Build... For Heavy Build Deduct 5%; For Light Build Add 5%).

BMI	% Variation in Weight from Ideal Weight
18.0	**-20**
20.3	**-10**
22.5	**0**
24.8	**+10**
27.0	**+20**
29.3	**+30**
31.5	**+40**

BMI	% Variation in Weight from Ideal Weight
33.8	**+50**
36.0	**+60**
36.3	**+70**
40.5	**+80**
42.8	**+90**
45.0	**+100**

(d) Percentage Body Fat Measurements From Skin Fold Thickness

Some practitioners prefer this method, as it involves a more direct measure of body fat. CAA forms allow for this method to be used, but we expect the result to be stated as a percentage estimate of total body fat. It is too complex a method to merit explanation here, and those using it are expected to complete the task: – don't leave the Assessor to do your sums for you!

3.2.3 The Resting Electrocardiogram

(a) Routine ECG Recording

(i) A resting ECG is routinely required at intervals indicated in AC67 Appendix V, according to the age of the pilot and the Class of Medical Certificate held. These intervals are determined by the likelihood that an ECG abnormality will have developed since the last examination and the acceptable level of risk permitted with the class of Medical Certificate issued. Those current at the time of publication are reproduced below:

- **Class 1**: initial Certification, and for the issue of Medical Certificates following the first examinations after the ages of 25, 30, 35, 38 and 40, and then annually thereafter;
- **Class 2:** initial Certification, and for the issue of Medical Certificates following the first examinations after the ages of 40, 44, 48, 52, 54, 56, 58, 60 and then annually thereafter;
- **Class 3:** initial Certification, and for the issue of Medical Certificates following the first examinations after the ages of 25, 30, 35, 38 and 40, and then annually thereafter.

(ii) The ECG must be recorded to a standard protocol (vide infra) and mounted as specified on the CAA ECG form.

(iii) A report on this tracing must be arranged (by agreement between the examiner and assessor). This can be provided either by the machine (when an automated electrocardiogram is used), or by a doctor (as specified in Volume 1, section 2.4b re ECGs). The tracing may be sent via facsimile to the reporting doctor, provided it can be clearly read and identified.

(iv) Then the ECG tracing, attached to a properly completed CAA ECG Report Form, must be sent to the Assessor who will issue the Medical Certificate.

(b) ECGs and Assessment by an AMA

[DME,AMA]

(i) **For initial certification** a properly completed ECG Report Form with tracing attached must have been completed and received by the AMA before the Medical Certificate may be issued.

(ii) **For recertification** *in cases where special attention is due because of previous concerns about the cardiovascular system* the same also applies. In other more routine cases for re-certification, the AMA has some flexibility if an ECG which is due has been inadvertently delayed.

(iii) The Assessor may issue a Medical Certificate if holding facsimile copies of the tracing and/or Report Form. When an automated ECG machine has been used, issuing its own interpretation of the recording, the Assessor may accept this provided it indicates normality.

(iv) **ECG Results:** *For all standard ECGs (and whenever an automated ECG report appears to identify an abnormality) the ECG tracing must be reported by a doctor on CAA's ECG Report Form.*

- EXTERNAL AMA ASSESSMENT: If the initial intention is for the assessment to be completed by an external AMA, this AMA is at liberty to decide who is acceptable to report on the ECG, and then may complete the assessment *provided this report indicates normality*. CAA does not accept this role of reporting ECGs for an external AMA to then assess, as this would be anti-competitive.

  If an ECG abnormality has been documented at a previous assessment this should have been flagged via an **Action Code of "N"** and perhaps other endorsements, with accompanying letter. This will ensure that subsequent reporting and assessment is completed only when holding relevant earlier records for comparison, to confirm there has been no significant change.

  However if such a report identifies a new abnormality of significance *(see 3.2.3c on interpretation),* ***then a CAA Medical Certificate must not be issued and the case must be referred to CAA.*** *At the least, a request form and* ***fee for Routine Assessment must be attached*** *(indicating that the ECG is the reason for referral). The applicant should be warned that a Special Assessment may become necessary (refer Confirmed Abnormality, below).*

- INTERNAL CAA ASSESSMENT: If the initial intention is for the assessment to be completed by an assessor at CAA, and *an ECG* ***abnormality*** *seems to be present,* and/or the reporting doctor is ***not a specialist*** *on the Register for internal medicine,* then the ECG received will be referred to CAA's own appointed specialist. In other words, when intending to send to CAA anyway it will often be an unnecessary duplication for the DME to refer the abnormality to an outside doctor for reporting.

- CONFIRMED ABNORMALITY: If the CAA specialist confirms an abnormality, this may be determined as having no safety consequence (with no further investigations being needed); or if a safety concern is raised, then a Special Assessment will be required (with further investigations being recommended). In either case, future assessment is to be flagged via an "N" Action Code as noted above.

(v) **Copies to CAA:** Once the Medical Certificate has been issued, the ECG tracing and completed Report Form is sent by the AMA to the CAA MU, together with the CAA General Medical Report form and other reports required, for filing on the CAA database. These tracings are available to Assessors for future comparison. In general the AMA who certifies should **retain the original ECG trace**, and it is sufficient for CAA to be sent a clear photocopy. However, it is preferred that original traces are sent to the CAA for retention if possible to ensure the highest copy quality.

(c) Special Resting ECGs

In addition to the routine requirements, electrocardiography may be required by an Examiner or Assessor if further cardiological evaluation is indicated by the findings of the medical examination.

(d) Electrocardiographic Standards

(i) **The protocol** for performing resting electrocardiography is described below, and must be complied with for certification purposes:

- A standard 12-lead electrocardiogram, recorded by normally acceptable techniques is required.
- Voltages of the recording must be standard (with a 1 mV calibration mark to indicate this); half standard calibration (with calibration mark to indicate this) is acceptable only when complexes are of unusually high voltage, and is unacceptable when used solely in order to fit multi-channel recordings of normal voltage complexes onto the paper (in which case the operator must override the machine's programming and ensure standard voltages are recorded).
- The electrocardiogram must be presented promptly so that the date it was recorded falls within the 90 days before the assessment (as required by CAR 67.19).
- The original tracing, suitably mounted according to the specifications on the form, must accompany the completed medical examination report form forwarded to the medical assessor.

(ii) **Interpretation:** The purpose of resting electrocardiography is primarily that of case finding. The relative insensitivity of the resting ECG will mean that a proportion of examinees may have serious coronary artery disease although their resting ECG is normal. Hence further examinations over and above a resting ECG will usually be necessary when the Examiner or Assessor suspects that cardiac disease may be present. This is elaborated on later.

On the other hand, when screening a young asymptomatic population, minor abnormalities are very common. Some ECG abnormalities may be regarded as ***benign variations*** in asymptomatic individuals, and may be accepted. Common variations that are considered acceptable in young asymptomatic individuals include:–

- sinus pause if less than 2 seconds;
- premature atrial beats;
- premature junctional beats;
- premature ventricular beats;
- atrial or junctional rhythm;
- supraventricular escape beats after a pause of less than 2 seconds;
- wandering atrial pacemaker;
- right axis deviation;
- left axis deviation;
- indeterminate QRS axis;
- PR interval **< 0.10** seconds;
- incomplete right bundle branch block;

(iii) The above variations may be accepted for the issue of a Medical Certificate when -

- the candidate is aged under 35;
- any cardiac symptoms have been specifically excluded by detailed questioning as described in Section 2.3.2.1 #b; and
- ***a specialist in internal medicine*** (in reporting on the ECG) ***recommends that in this specific case the ECG abnormality be accepted as a benign variation.***

The remainder of Section 3.2 is optional material regarding Special Assessments, for the information of AMAs.

(e) The Exercise Electrocardiogram

[AMA]

(i) **Purpose of Exercise ECGs**

Exercise (or stress) ECG testing increases the predictive value of the ECG in identifying coronary disease. The interpretation of the findings of exercise testing is not free of problems however, and the use of this investigation for mass screening of asymptomatic individuals for coronary disease is not indicated; ***its use will necessitate a Special Assessment.*** Exercise electrocardiography may be required for those who have symptoms which suggest the presence of ischaemic heart disease; those who are found on screening and cardiac risk factor analysis to be at increased risk for ischaemic heart disease; those in whom there are ECG or clinical variations that require further evaluation; those known to have heart disease, as part of the assessment of severity; and so on...

(ii) **Protocol for Exercise ECG Tests:** During exercise testing, the patient walks on a moving belt in stages of both increasing speed and inclination.

- *Beta blocking agents and other cardioactive medications ideally will have been withdrawn 48 hours beforehand (digoxin 10 days).*

The **Standard Bruce Protocol for exercise electrocardiography** or equivalent may be used. Throughout the test, it is desirable that all 12 standard leads of the electrocardiogram are available for analysis at any one time. Some cardiologists use only 3 leads for assessment and CAA cannot decline to accept such recordings. ECG recordings are taken during stress, immediately after stress, and then at 2 minute intervals for at least 6 and up to 10 minutes.

Systolic and diastolic blood pressure recordings should be taken during and after stress. The purpose of the test is to produce controlled stress on the cardiovascular system. Exercise should be terminated when the maximum predicted heart rate has been achieved. A test terminated because of induced symptoms may be considered by CAA as abnormal. A test terminated when less than 85% of the MHR has been attained will not usually be regarded as normal. It will thus be necessary for any candidate who is on treatment with a beta-blocking agent to stop that treatment for a period before a treadmill test.

(iii) **Interpretation of Results:** The major objective of the exercise test is to assess the contour of the S – T segments during and after stress. The criteria for assessing a test as positive when changes suggesting inducible ischaemia are met are often debated unless a significant change is demonstrated in a

subject whose resting ECG shows no S-T -T abnormality. (debates arise in deciding what is "significant" but in general there would not be debate about depression of 1mm or more.)

- ***To ensure that an objective and uniform assessment is made, the full ECG recordings taken during such tests are to be forwarded to CAA with accompanying reports, as part of a Special Assessment.***

3.2.5 Isotopic Myocardial Perfusion Imaging

(a) Myocardial perfusion imaging is regarded as a useful method of non-invasively evaluating the presence of significant coronary artery disease. This is based on the premise that myocardial uptake of a radio-isotope is in direct proportion to coronary blood flow. Various radio pharmaceuticals are available for this, the most common being the technetium-based Isonitriles.

(b) The patient undergoes a myocardial perfusion scan both at rest and with stress (either exercise induced or pharmacological). An initial SPECT and planar scan is performed with the patient supine beneath a gamma camera. Up to four hours later a further stress SPECT and planar scan is performed with injection of the radio tracer 1 minute before peak exercise or 3 minutes following Persantin injection. Following acquisition of the information the images are formed, comparing the same region of left ventricular myocardium.

(i) In the normal heart, both images will appear the same.

(ii) A reversible defect seen on the stress study alone is consistent with ischaemia.

(iii) A persistent defect seen in both studies is compatible with completed myocardial infarction.

(c) In addition to the static SPECT and planar imaging, the stress scan can be gated to demonstrate left ventricular wall thickening and contractility. This gives an added dimension to the accuracy of the report. Attention to patient presentation, as well as acquisition and processing of data is essential in producing high quality and accurate myocardial perfusion images which can then demonstrate non-invasively whether significant coronary artery disease is present.

(d) Standard indications for isotopic myocardial perfusion studies include the presence of equivocal exercise tests; left bundle branch block; arrhythmias; patients in whom adequacy of revascularisation requires assessment; to determine whether an equivocal coronary lesion is significant; or to detect hibernating myocardium.

(e) The quality of the images obtained and thus the reliability of the interpretation of results depends on the type of facility that is available and on the skill and experience of those undertaking the study. An independent review of isotope results is always appropriate and ***when such tests are done, the photographs will be reviewed by CAA's advisers.***

3.2.6 Coronary Angiography

(a) Angiography is necessary if detailed information on coronary anatomy is required. As with all invasive investigations, there are associated risks and so CAA will never direct a pilot to have such a study carried out. On the other hand pilots will know that in some circumstances license status may not be assessable without information on the coronary anatomy. It is for the applicant to decide whether to accept the investigation and it would be expected that this decision would be made after full discussion with his/her own medical advisers.

(b) Angiography is likely to be required if there is a strong suspicion of presence of coronary disease; following a myocardial infarction; to assess the outcome of an intervention such as CABG or PTCA, and in a variety of other circumstances.

3.2.7 Ambulatory Cardiac Monitoring

24 Hour Holter monitoring is frequently helpful in the assessment of cardiac arrhythmias and may be asked for in specific cases.

3.2.8 Cardiac Ultrasound

(a) Cardiac ultrasound may be used in cross-sectional mode or M-mode format to evaluate the structural normality of the heart. 2 dimensional Echo studies have now largely replaced the M-mode tests used earlier. This non invasive simple investigation is used to assess valve structure and function, to assess the wall thickness and volumes of the heart's four chambers, to measure the thickness of the myocardial walls of each chamber, by measurement of the end systolic volumes and the end diastolic volumes of the left ventricle. This gives an indication of the pump's efficiency which can also be determined by measurement of the ejection fraction.

(b) A number of other parameters relevant to cardiac dysfunction can also be measured (e.g. an assessment for presence of pulmonary hypertension, pericardial effusions, intracardiac tumours, focal abnormality of ventricular wall motion as may occur after infarction). Addition of Doppler studies gives a capacity to measure the volume and direction of intra-cardiac blood flow, allowing an accurate check on valve function (i.e. presence of stenosis or incompetence) and also to determine presence of any intra cardiac shunt.

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3.3 Coronary Artery Disease

3.3.1 General

[DME,AMA]

(a) The Natural History of Coronary Artery Disease

The typical atherosclerotic lesion seen in the arteries of most adults is the atheromatous plaque. This can increase in size at a variable rate, influenced by various coronary risk factors, some known and some unknown. When the lesion occupies greater than 50 percent diameter of the coronary vessel, it may induce coronary insufficiency with exercise but critical reductions in blood flow do not usually occur until this narrowing exceeds 80 percent.

Sudden changes in a plaque, ***even when there is only minor narrowing***, may occur (rupture with or without a precipitating intimal haemorrhage) resulting in damage to the endothelial surface which in turn leads to thrombus formation. Artery occlusion thus occurs with myocardial infarction often resulting.

(b) Coronary Artery Disease and Fitness for a Medical Certificate

The prevalence of the disease, in various stages of severity, in the population of pilots and air traffic controllers with Medical Certificates and the frequency of silent disease leads to concerns about the need for the screening of candidates who may be at risk of sudden incapacitation from coronary artery disease. The problems of screening are explained in more detail in the next section.

Because the first presentation of coronary artery disease in 15% of cases is sudden death, with sudden collapse due to arrhythmia or ischaemia occurring in a further group, medical certification must take all reasonable steps to identify those candidates who may have coronary artery disease, even if it is asymptomatic at the time of examination. For this reason, risk factor analysis is desirable to try to identify those individuals who are at increased risk of incapacitation because of coronary artery disease.

The presence of risk factors is not disqualifying per se, but indicates that further special testing may be appropriate before a Medical Certificate is issued. Risk factor analysis may also be applied to candidates who are known to have coronary artery disease, but who may fall into a sub-group of those who are less likely to have further symptoms.

3.3.2 Risk Factors For Developing Coronary Artery Disease

[DME,AMA]

(a) Relative Importance of Risk Factors

Risk factors implicated in the development of coronary artery disease have been derived from the Framingham heart study. The most significant of these are **age and gender,** though the bias towards males is reducing. There now appears to be an increasing incidence in pre-menopausal women and chest pain in such subjects must not be presumed to be non-cardiac.

The relationship between age and the risk of death from ischaemic heart disease is exponential. Compared with the risk of a 30 year old (of having significant coronary artery disease causing death) – a 40 year old is eight times; a 50 year old is 36 times; and a 60 year old is 100 times more at risk.

The risk of sudden death in male populations is highly correlated with hypertension, hyperlipidaemia, obesity and cigarette smoking. There are two categories of risk factors:–

(i) **Fixed risk factors** including age, race, family history, physique, sex;

(ii) **Controllable risk factors** including obesity, cigarette smoking, lack of physical exercise, stress, hypertension and hyperlipidaemia;

The **Dundee Risk Disk** helps clinicians to focus on the controllable factors, in order to adopt a practical approach to education of those at higher risk. However, it should be noted that the result of the disk's calculations is a ranking of the individual within his or her age/sex group. It does not produce an indication of absolute risk, which is the concern of CAA MU (who tend to prefer using calculators or computer programmes to derive a numeric value for risk of a cardiovascular event per annum). Nevertheless, the Dundee Risk Disk is recommended as a useful approach to preventive medicine by DMEs and AMAs.

The role of stress and personality, in particular Type A personality, is much less clear. Some studies have shown that Type A individuals who are more aggressive, ambitious and competitive than Type B personality types, are at increased risk of developing coronary artery disease. Many pilots exhibit Type A personality traits and for this reason it may be that pilots are more at risk for developing coronary artery disease than other occupational groups. It is important to realise that coronary risk factors may not be simply additive in their combined effects on mortality. Thus cigarette smoking combined with a family history may be a much more potent combination than hypertension and smoking.

(b) Hypercholesterolaemia

Data from the Framingham study demonstrated quite conclusively that the incidence of coronary mortality was related to total serum cholesterol levels with a particularly high incidence above cholesterol of 8.0 mol/litre. Total serum cholesterol is less significant as a risk factor than its ratio to HDL cholesterol and LDL cholesterol. HDL cholesterol is protective against coronary disease and its level in plasma should be taken into consideration. High density lipoprotein (HDL) cholesterol normally

accounts for about a quarter of the total plasma cholesterol and the HDL cholesterol appears to be cardio-protective and is inversely related to the likelihood of developing coronary artery disease.

The ratio between the total serum cholesterol and the HDL cholesterol is a more sensitive indicator of actual cardiovascular risk. The ratio of total to HDL cholesterol should ideally be less than 4 and ratios of greater than 6 are strongly associated with coronary artery disease. HDL cholesterol can be influenced by many life-style factors and is independent of age during adult life. Dietary consumption of cholesterol and saturated fats reduce HDL cholesterol levels and moderate alcohol intake has an apparently beneficial effect on increasing HDL levels. Physical activity also elevates HDL levels and this may be a causative factor in the reduction of coronary artery risk amongst regular exercisers. The effect is most marked with vigorous physical exercise and marathon runners for instance have a higher level of HDL cholesterol than joggers. Smoking decreases HDL cholesterol levels and it may be that part of the risk of developing coronary artery disease through cigarette smoking may be mediated through the HDL cholesterol level.

There is no clear relationship between triglycerides and the risk of developing coronary artery disease. Fasting lipids should be tested if indicated by risk factor analysis, or if you consider this a worthwhile part of your health promotion programme for the candidate.

(c) Tobacco smoking

Cigarette smoking is a significant risk factor for developing coronary artery disease and the level of increased risk is related to the level of consumption. The risk of coronary artery disease will decrease if a previous smoker quits smoking but the risk actually takes several years to decline. The Dundee Risk Disk illustrates this phenomenon well.

The major effects of smoking on the cardiovascular system are the stimulation of the sympathetic nervous system by nicotine and the displacement of oxygen from haemoglobin by carbon monoxide. Other postulated mechanisms include an induced immunological reaction of the vessel wall related to some constituent of smoke and potentially some increase in platelet stickiness. Cigarette smoking also lowers HDL cholesterol, and increases the risk of myocardial infarction and coronary heart disease in women taking oral contraceptives.

(d) Hypertension

Hypertension has been well established as a risk factor for coronary atherosclerosis, but the treatment of hypertension may not reduce the incidence of clinical coronary heart disease or myocardial infarction, as it does for stroke and renal failure.

(e) Diabetes

The frequency of acute myocardial infarction and likelihood that it will cause death is increased in diabetic patients. Cardiac autonomic dysfunction also exists in many diabetic patients, and may be an aetiological factor in the increased incidence of cardiomyopathy seen in diabetics. Another aetiological factor in this condition is the tendency of atherosclerosis to involve small intramural coronary vessels in preference to the larger epicardial coronary arteries. It is important to realise that significant left

ventricular dysfunction may exist in diabetics in the complete absence of cardiac symptoms. ***It is now suggested that tight biochemical control of diabetes may result in a reduced incidence of cardiovascular manifestations of the disease.***

A full cardiovascular assessment should be made in all newly diagnosed adult diabetics. A minimal evaluation would include electrocardiography, both at rest and during exercise, to evaluate potential myocardial ischaemia and echocardiography to assess left ventricular function.

(f) Family history of premature coronary artery disease

Family history alone is an independent predictor of coronary disease and a family history of cardiovascular disease before the age of 65 in any relative is a mild risk factor for developing coronary artery disease, perhaps because of associated factors such as a family history of hyperlipidaemia, hypertension or diabetes.

(g) Prevention of Coronary Artery Disease

Many risk factors are not subject to modification such as age and sex. However, avoidance of cigarette smoking, including passive smoking, a proper diet, maintenance of a reasonable body-weight, low dietary fat intake, and prompt treatment of hypertension should do much to reduce the risk of premature medical retirement due to coronary artery disease amongst pilots. Certainly pilots should be advised to have a serum cholesterol estimation done and make suitable dietary modification if abnormal lipid profiles are seen. Alteration of Type A behaviour is rather less easy, but certainly stress management programmes and recommending stress avoidance may be useful if difficult to put into action. Physical exercise may certainly be advocated but should normally be done so with caution in patients over the age of 35. Older patients should also be recommended to exercise progressively from minimal physical activity to an active programme. Diet, while controlling lipids, may also be necessary to reduce obesity and control hypertension.

(h) Implications for Assessors:

CAA-appointed assessors should pay appropriate attention to screening asymptomatic individuals for cardiovascular risk factors in order to identify those with significant vascular disease before the risk of pilot incapacitation becomes excessive.

3.3.3 Screening For Coronary Artery Disease

[AMA]

(a) Limitations on Screening

A resting ECG, if used in unselected asymptomatic populations, has low sensitivity so is not an effective screening tool to exclude ischaemic heart disease.

Whilst stress ECG may have greater value in detecting asymptomatic coronary disease it has poor specificity. This means that routine screening of asymptomatic low-risk individuals using stress ECGs produces many false positive results.

(b) Cost implications of screening

Investigating these false positives carries costs in terms of the risk and discomfort associated with unnecessary invasive investigations such as scintigraphy or coronary arteriography. In addition there are financial costs both to the individual and to the health services. All these are clearly undesirable. An alternative approach is to assess those who at higher than average risk of coronary artery disease more aggressively.

(c) Risk Assessment of Candidates For Screening

Because pilots are subject to regular medical checks, as well as being relatively young and tending to self-select for medical fitness, the prevalence of myocardial ischaemia amongst the overall pilot population tends to be very low. However, by selecting those at higher risk by virtue of age, male gender, cigarette smoking, hypertension, obesity, family history and diabetes, a subgroup can be found who require further evaluation. Various methods for assessing risk by use of calculators and even computer based programmes are at times used. These are often based on Framingham data. The chart of **Appendix B** is a simple method based on this, but should be ***interpreted with care***.

This evaluation will be helped by assessment of the levels of ***serum cholesterol (and other lipids) at the first opportunity at or after the age of 30 years*** for every pilot or ATCO. At present this is only a CAA recommendation for screening, but may become mandatory if written into CAR67 later. Until then it cannot be insisted upon unless there are other reasons to be concerned (e.g. obesity, smoking, hypertension, particularly in those over age **40** years). ***In those found to be at borderline or higher risk of CAD, serum lipids should be repeated every 10 years subsequently***.

For those above age 35 years with an unsatisfactory risk profile, a **stress ECG** may be necessary in asymptomatic individuals. A positive stress ECG must be followed by further investigation to determine whether the abnormality is due to coronary disease. In centres where facility exists to undertake high quality myocardial perfusion studies, such would be the logical "next step" in the assessment process.

The remainder of Section 3.3 is optional material regarding Special Assessments, for the information of AMAs.

3.3.4 The Special Assessment of Aircrew with Coronary Artery Disease [AMA]

The remainder of Section 3.3 is material of whose existence AMAs need to be aware, if they are to assist an applicant through this process. It would be wise, when a new case arises, always to check with CAA whether there has been a recent revision of these criteria. To avoid too much repetition, and also since an individual may have had both infarction and intervention, the criteria after infarction and after intervention have been combined into one sequence. It should be evident which items are appropriate when considering an individual case.

(a) Introduction

The risk of sudden incapacity in an individual with coronary artery disease is such that when this diagnosis is established the pilot will be assessed as unfit until the condition has resolved (either spontaneously or as a result of treatment). In terms of intervention, this implies CABG or Angioplasty.

CAA's policy is not to make any recommendation on such intervention, since such advice would be inappropriate to CAA's role. Sometimes intervention is not clinically indicated, and the question of CAA certification is the only pressure leading the patient to consider intervention. It would be improper for CAA to appear to be espousing treatment which the clinician may not clinically support. The decision regarding the need for an intervention and the indications for it must remain between the patient and the clinician.

The following criteria developed by the CAA Medical Unit have been reached after careful review of standards set down by other aviation authorities (USA, Australia, UK, Europe and Canada) Whilst there are differences in the criteria set out by these authorities the CAA unit has tried to reach a balance between those that are in their view too liberal and those that appear to be too conservative.

In presenting criteria for fitness, three categories are considered. These are

1. Assessment after an acute coronary syndrome;

2. Assessment in an asymptomatic pilot with CAD;

3. Assessment after CABG and/or Angioplasty.

These criteria are presented in a form which will serve as a guide to AMAs, and may be released under the Official Information Act. However, it must be borne in mind that the process of special assessment is a dynamic process which is always subject to review. It is therefore preferable for an individual applicant to confirm by direct request to the CAA MU what are the current criteria applying.

(b) NOTE ON ANGIOGRAPHY:

Confusion has arisen in the interpretation of the degree of narrowing (stenosis) that may be seen in coronary arteries.

- Internationally, the majority quantify the degree of narrowing by quoting the *reduction in luminal diameter*.

- Some experts, particularly in New Zealand, prefer to assess the degree of narrowing as the *loss of cross-sectional area* as defined from derived data of longitudinal sections during angiography.

These two methods are mutually incompatible. Since the mixing of the two can lead to confusion, the CAA Medical Unit prefers that the former internationally accepted terminology is used in reports provided for Special Assessment.

(c) LEVELS OF RESPONSIBILITY vs. ~~vs~~ SAFETY:

These criteria take account of the important differences between Class 1 and Class 2 licences. These relate on the one hand to the increased responsibilities of Class 1, and on the other hand to the generally agreed freedom that Class 2 should expect to enjoy. This is further complicated, however, by the differences in the safety factor for multicrew flying versus solo flying. This results in more stringent standards for Class 1 CPL than for Class 1 ATPL, in situations where incapacity is at risk. Hence, concessions available to ATPLs are not necessarily to be permitted for CPL. See section 2.3.1.2 on Risk Assessment for details of this approach.

(d) PRIVATE PILOT RESTRICTIONS:

In the Class 2 (PPL) situation, the question of a safety pilot is complex:

(i) Some private pilots who fail the criteria of this section may ***seem*** to be safe to be re-certified provided there is the additional protection of a second pilot on the aircraft to take over control, thus reducing the risk of a disastrous loss of control. Some authorities use restrictions such as valid only ***"as or with a co-pilot"*** or ***"with a safety pilot in an aircraft fitted with dual controls".*** CAA does not support this approach, as failure to define precisely who may act as "safety pilot" could lead to an "at risk" pilot endangering not one but two aircrew. CAA's stance is that a safety pilot in this context should be a Qualified Flying Instructor (QFI) trained and experienced in monitoring the flying performance of the other pilot in his care, and able to take over control in difficult circumstances. The aircraft would obviously have to be fitted with complete dual controls. As anyone may fly without any licence or CAA Medical Certificate with an appropriately qualified QFI as pilot-in-command, and may fly the aircraft for the purpose of training, this provides an informal provision in New Zealand for a pilot (at high risk) to fly in the dual situation without requiring a decision concerning fitness to fly. ***It is appropriate to tell those at high risk (exceeding 1% p.a.) about this opportunity to continue flying under these circumstances. However, since it is the Flying Instructor's decision whether such flying is safe, the patient is***

under an obligation to inform the Chief Flying Instructor of the exact medical condition causing added risk.

(ii) Private pilots may also wish to note in section 3.3.10 the possibility of avoiding the need for angiography, provided a restriction (#132) can be accepted.

3.3.5 Special Assessment after Intervention or Acute Coronary Syndrome

(a) A pilot with CAD requiring intervention (CABG, Angioplasty), or with an acute coronary syndrome (such as Infarction) not resulting in intervention, will be assessed as Temporarily Unfit. Further re-assessment would not be considered earlier than 6 months later (either after successful intervention or after the acute syndrome has resolved fully).

(b) *In all cases, the extent of the underlying coronary artery disease and other factors relevant to the risk of future events will be considered, with the purpose of trying to determine the risk of a further cardiac event.* CAA sets the limit for acceptable risk as being less than 1% per annum.

(c) Requirements for consideration of special issuance are discussed in the next two sections, and then in 3.3.9 a combined set of criteria for assessment are listed for both situations. These criteria remain generalisations, since it is difficult to set absolute rules for coronary artery disease. Each case will be judged on its own merits.

(d) **Angiography:** Last on the list of criteria is angiography, and in view of its cost and associated risks, it is advised that this usually be not embarked on until an interim assessment from CAA indicates that all other tests are sufficiently promising to merit proceeding to angiography. Further, a restricted license can be considered for some Class 2 pilots who have *not* had a repeat angiogram following an intervention (see section 3.3.10). Issue of a license of that type will not be available for a pilot whose pre-operative angiogram showed extensive CAD or who had not had full re-vascularisation.

(e) *These criteria should be used as a sequential checklist by the applicant's medical advisers, and it is generally recommended not to proceed to items later in the list if serious failures are demonstrated in earlier items. Criteria (c) and (d) are listed early since cardiologist review is advisable early in the process. However, the process of evaluation sometimes suffers setbacks and delays, and there may later be a need to provide an updated report to satisfy these two criteria.*

(f) *It is also advised that sending CAA an incomplete set of reports (particularly if these reports suggest some failure of these criteria) may render the process of assessment unnecessarily expensive and prolonged for the applicant. It is CAA policy to assume (unless otherwise advised) that an applicant submitting incomplete reports is seeking an interim assessment on which to base a decision whether to proceed further. After this interim assessment is notified to the applicant, any further submission of reports would then require a further request for assessment (with new fee).*

3.3.6 Special Assessment after Acute Coronary Syndrome

(a) Acute Coronary Syndrome refers to events such as myocardial infarction, an episode of unstable angina or other type of symptomatic ischaemia. A pilot who has such an acute event and who is regarded now as being at an acceptable level of risk may be re-certified via special issuance.

(b) In the absence of more precise statistical data, acceptable risk may be suggested by normal ventricular function; normal exercise studies; no demonstrated significant coronary stenosis in a vessel remote from any infarction; and the absence of such features as dysrhythmia, previous infarction, or persisting angina. Those features, if present, would mean that a pilot should not be re-certified.

3.3.7 Special Assessment after CABG &/or Angioplasty

(a) Requirements for consideration of special issuance would involve assessment of efficacy of the intervention in establishing adequate myocardial perfusion and an assessment of the risk for recurrence of ischaemia. In general, assessment will look for maintained dilation after angioplasty; and will have regard for the knowledge that Internal Mammary Artery (IMA) grafts have a more favourable long term outlook than saphenous vein grafts.

(b) Although a restricted Class 2 certificate (see 3.3.10) can be considered for some pilots who have *not* had a repeat angiogram following the intervention, it should be noted that issue of a Class 2 certificate will be not be available for a pilot whose pre-operative angiogram showed extensive CAD or who had not had full re-vascularisation.

3.3.8 Special Assessment with neither Symptoms nor Intervention

If a diagnosis of coronary disease has been established in a pilot who has not at any time had related symptoms, the assessment approach will be similar to that required in 3.3.9.

3.3.9 Criteria After Intervention or Acute Coronary Syndromes

(a) By intervention is meant procedures such as CABG and Angioplasty. Acute Coronary Syndromes include, for example, infarction.

(i) Special Assessment should be no earlier than ***6 months*** after the event (either after successful intervention, or after resolution of infarction or other acute coronary syndrome)***;***

(ii) Since assessment will involve an exemption, this is available for re-certification only; Experience should not be less than 2,000 hrs CPL/ATPL or 200 hrs PPL;

(iii) ***A report from a cardiologist dated not more than 42 days prior to receipt of the request for assessment*** indicates there are no cardiac symptoms and no ongoing drug treatment for control of symptoms (although, for example, prophylactic medication to influence platelet function, hypertension and hyperlipidaemia is acceptable).

(iv) Risk analysis ***of current information provided with the cardiologist's report*** shows that previously elevated modifiable risk factors are now controlled (i.e. no obesity above BMI of 30, lipids acceptable, normal blood pressure, non-smoker, normal fasting blood sugar, adequate exercise);

(v) Successful completion, ***within the previous 3 months***, of Bruce Protocol treadmill ECG to a heart rate of 160/min or to 90% of MHR, with no evidence of inducible myocardial ischaemia and with an appropriate blood pressure response. Beta blocking agents and other cardioactive medications ideally will have been withdrawn 48 hours beforehand (digoxin 10 days). ***See NOTE 1 & 2.***

(vi) In cases where there is suspicion of dysrhythmia, Holter monitor for 24 hours, ***within the previous 3 months***, shows no significant rhythm or conduction disturbance.

(vii) Echocardiography/radionuclide/contrast ventriculography, **within the previous 3 months**, demonstrates an ejection fraction exceeding 50%, with 2D echo confirming that there is no significant abnormality of wall motion worse than localised hypokinesia.

(viii) Recent satisfactory angiography (carried out at least 6 months post-intervention *or post-event*, and produced for assessment within 42 days of assessment date). ***See NOTE 3 & 4.*** This must show no more than minimal disease ***(i.e. no more than 50% diameter reduction in a major vessel remote from any myocardial infarction; in untreated vessels, and in distal parts of any grafted vessel)***.

(ix) With the increasing evidence of good long-term patency of IMA grafts, pilots who have had that type of intervention are more likely to be eligible for special issuance. The less favourable long-term patency of vein grafts will jeopardise special issuance to those who have had that type of graft (either as the definitive procedure or to supplement IMA grafting);

(b) **NOTE:**

(i) Exercise ECG can only be technically adequate if medication that prevents the achievement of MHR is discontinued for the appropriate period before the test is performed.

(ii) For the purpose of special issuance photocopies and facsimiles of ECGs, or reports without attached ECG tracings, are unsatisfactory. Originals of ECG tracings must be sent. If asked to return these CAA will do so promptly after taking copies.

(iii) For the purpose of special issuance, the report of any angiography needs to include a copy of a diagram summarising the findings.

(iv) Private pilots with suspected or proven CAD and with satisfactory non-invasive tests ***(i.e. excluding the last two criteria, h & i)*** might nevertheless be assessed as fit provided restriction **#132** is applied to their CAA Medical Certificate. Restriction #132 is a way of rendering the level of risk acceptable (see below)**.** Angiography demonstrating compliance with CAA's criteria may avoid the need for such a restriction, *provided the risk for a coronary event is at or below the 1% limit*.

3.3.10 Procedure after Assessed as Fit

(a) Restrictions on CAA Medical Certificate:

- **Class 1:** "131: Valid only for multicrew operations in an airline with approved incapacitation training".

- **Class 2:** *Provided angiographic criteria above are met, and risk of coronary event is considered to be of the order of 1% or less,* ***no restriction***.

- **Class 2:** Otherwise, if non-invasive test criteria are used instead, or if the risk exceeds 1%, the following restriction must apply:

  "132: NOT VALID FOR – carriage of passengers; glider towing; unpressurised flight above 8000 feet; flight over built-up areas (circuit exempt); IFR flying; international air navigation."

(b) Pilots found fit under the above criteria would have future assessments based on similar criteria. Follow-up reports required would be as follows.

- Annual follow-up review by a cardiologist, with exercise ECG/scintigraphy.

- A further angiogram may be required, no later than 5 years after the index event unless the exercise study results are impeccable. A repeat angiogram will be required at any stage if there is concern about possible progression of the coronary disease.

References:

1. An appraisal of cardiovascular standards for Australian civilian flying licences. Vohra J., Plowright R. Aust NZ J Med 1989; 19: 76-82.

2. The Second UK Workshop in Aviation Cardiology. European Heart Journal, May 1988; 9; Supplement G.

3. Guidelines for the Assessment of Cardiovascular Fitness in Canadian Pilots, 1988. Nov 1988. Civil Aviation Health Advisory Services, Medical Services Branch.

4. Review of Part 67 of the Federal Air Regulations and the Medical Certification of Civilian Airmen. 1985. American Medical Assoc.

5. The First European Workshop in Aviation Cardiology, December 1992; European Heart Journal 13; supplement 14.

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3.4 Hypertension

[DME,AMA]

3.4.1 General - Assessment Concepts

Hypertension is a common disorder and affects nearly a quarter of the adult population. However, in terms of aviation, the issues regarding assessment are fairly straightforward. These are therefore summarised on this page, and further details are integrated into subsequent sections (in lieu of a later heading on Assessment).

(a) Hypertension itself will *not cause immediate concern*, in terms of fitness during the currency of a Certificate issued *today*, unless it exceeds limits defining *severe hypertension* (i.e. with a significant risk of sudden or subtle incapacity). Since this is a pivotal question an attempt is made to specify these limits, in *section 3.4.2 Blood Pressure Limits.*

(b) *Treatment* will be advised for a person with lesser degrees of hypertension, and so the most common aviation concerns involve deciding whether medication is required and then considering possible *undesirable effects of treatment* and whether *stability of control* has been achieved. This results in an emphasis on a relatively brief "ground trial" of drug treatments initially, in preference to a prolonged period of "temporary unfitness". These concerns are discussed in *section 3.4.5 Treatment.*

(c) CAA's concern with the long-term effects of hypertension relates to risk factors for vascular disease. While this is an *essential part of the ongoing assessment of those with hypertension*, it has already been covered in the previous section and will not be laboured here. See sections 3.1.2 The Risk Assessment Process & 3.3.2 Clinical Examination.

(d) It follows from the above, that provided a DME produces and maintains adequate and accurate records, potential problems can be reduced. Much of what follows relates to ensuring that records of investigation are satisfactory (sections 3.4.3 onwards). If this advice is followed, most cases of hypertension will remain an entirely routine assessment matter.

3.4.2 Blood Pressure Limits

(a) General

(i) It is essential to establish that the diagnosis of hypertension is correct. This should not rest on two or three casual observations of blood pressure, since hypertension can be labile or reactive and not need treatment. To confirm a diagnosis of hypertension requires careful assessment over a period of two to three months, with repeated readings taken for periods up to 30 minutes, particularly when the elevation of readings is marginal. An often forgotten need is the use of a large cuff in patients with large arms.

(ii) This effort is needed because in many hypertension trials it has been shown that up to one third of the patients initially diagnosed as hypertensive have been shown after subsequent analysis to be normotensive. Unless an individual has other major risk factors for the development of vascular disease, it is doubtful whether any long term benefit is achieved by treatment of diastolic pressures under 100 mm of mercury. Useless treatment wastes money and effort and also in itself can cause unnecessary problems.

(iii) In the older age groups, systolic pressures may rise progressively while the diastolic pressure remains normal. This is a physiological process resulting from decreased elasticity of peripheral vessels, and aggressive measures to bring systolic pressure down may have significant adverse effects.

(iv) Borderline hypertension plays only a small part in increasing the risk of sudden incapacitating coronary artery or cerebrovascular events when compared with other risk factors such as sex, age and cigarette smoking. This must be born in mind when setting upper limits for acceptable readings, so as to avoid being too inflexible.

(v) It is more appropriate to set decision points (beyond which investigation and/or treatment should occur) than to set absolute limits ("fitness standards") beyond which a person would be considered not fit.

(b) Decision Points for Hypertension

Each case is assessed individually, taking into account the candidate's age, other cardiovascular risk factors and previous blood pressure readings.

(i) If an applicant has normal blood pressure or this is borderline (without complications), CAA is satisfied for AMAs to assess as FIT *without further investigation*.

(ii) BORDERLINE HYPERTENSION: The boundary between normal blood pressure and significant hypertension is such that if 3 blood pressure readings lying exceed the following limits, then there is significant hypertension. The following are action levels (not cut-off points for FIT assessment): --

- at less than 40 years - 145/90 mm Hg;
- at 40 - 49 years - 155/95 mm Hg;

- at more than 50 years - 160/100 mm Hg.

(iii) SIGNIFICANT HYPERTENSION: CAA is satisfied for an AMA to assess as FIT while further investigation proceeds as in section 3.4.4, provided the limits specified in the next section are not exceeded. Any period of "grounding" would usually only be the minimum necessary during introduction of any treatment (see later).

(iv) UNFITNESS WITH HYPERTENSION: AMAs may not certify fitness in the presence of significant hypertension when

- *there is also suspicion of* ***co-existing cardiac, vascular or renal disease****;*
- *and/or the following limits are exceeded --*
  Systolic BP persistently exceeding ***180 mm***; or
  Diastolic BP persistently exceeding ***110 mm***.

In such cases, there should be a Notice of Unfitness issued and/or assessment as Temporarily Unfit.

3.4.3 Blood Pressure Recording

The principles of measuring blood pressure are adequately taught elsewhere, and need not be repeated here.

The patient should as far as possible be relaxed and the arm well supported. The diastolic pressure should be recorded as phase 5 of the Korotkoff sounds, that is the point of disappearance of sounds. It is very important to remember to use the appropriate cuff size, with a larger cuff needed for those with a large arm circumference.

There is debate whether readings are best taken with the subject lying or seated. Lying readings are generally favoured as most subjects seem more able to relax in that position. However, some individuals seem to feel "vulnerable" with a white coat standing over them. As long as the subject is relaxed with arm supported in extension and not conversing, the appropriate posture acceptable to CAA is that which results in the lowest and most stable readings.

(a) If the initial reading gives a systolic pressure below 140 and a diastolic below 85, no further readings are needed.

(b) If levels are higher, repeated readings at 2 minute intervals will be required with a concurrent record of the pulse rate. Such additional readings are also necessary for subjects who are on hypertensive medication.

(c) Standing readings are needed for those in whom a significant postural drop could occur (e.g. the elderly, in hypertensives under treatment, or in the presence of other situations where postural hypotension is possible) With the subject standing for at least a minute, take at least one reading of the standing blood pressure with the arm extended and supported, plus a record of the pulse rate.

3.4.4 Other Methods of Blood Pressure Recording

Many clinicians are supplementing their own readings by other methods.

(a) Some involve nursing colleagues in assessing serial measurements. Results of such tests are often contributory.

(b) Others promote home self check readings by the patient. For that purpose a variety of automated devices are now marketed. If they are used in the setting of pilot assessments, the accuracy of the device needs to be confirmed by the clinician who will check the results of simultaneous standard measurements with those of the device used. Such home pressure checks can be useful on the occasions when the significance of minor elevation of readings is questioned or when the effects of therapy need to be closely monitored. In general it is inappropriate to base management decisions solely on the basis of home readings.

(c) In some centres intra arterial mobile BP monitoring is promoted in the assessment of hypertension and this technique can be helpful. If monitoring of this type is advised for a pilot who wishes to have that investigation, the results will contribute to management decisions.

3.4.5 Investigations in the Hypertensive Pilot

(a) Where significant hypertension is confirmed, further investigation is guided by the completion of a CAA24067**/214 BLOOD PRESSURE form** *(or until first publication of this, the older* ***MOT1309*** *Hypertension Report form)***,** to include the following: --

(i) An **ECG**, if one has not been recorded within the last 12 months.

(ii) **Initial blood tests** to include serum potassium, creatinine, uric acid, fasting glucose and serum lipids.

(iii) If beta-blockers are to be given, a pre-treatment record of peak flow **and/or spirometry** is required.

(iv) Other investigations may be appropriate in certain subjects.

- Until recently a **chest X-ray** was considered to be one of the routine tests suggested for such persons. It is now accepted that a chest X-ray will not give useful information unless there be a suspicion that LV failure is present.

- **2 D Echo test**: This investigation which is being utilised with increasing frequency to exclude or confirm presence of LV hypertrophy in the patient with hypertension, may be advised in certain cases.

- other investigations to exclude presence of secondary hypertension may be necessary.

(b) PREVIOUS RECORDS: When seeing a patient who is noted for the first time to have an elevated blood pressure, it is important to attempt to locate previous

records of blood pressure measurements which may be held by the patient's general practitioner.

(c) PULSE RATE: It is important to consider the pulse rate when assessing the significance of elevated blood pressure readings.. A tachycardia would suggest that the patient has been particularly anxious with resulting elevation of readings. A very slow pulse may suggest that the patient had self-administered beta-blockers prior to the examination. This was one of the more common ploys used to deceive medical examiners in civil aviation medicine. However, a relatively slow pulse may instead be an indicator of successful cardiac conditioning due to regular exercise.

(d) TARGET ORGAN DYSFUNCTION: Because hypertension is a factor promoting development of atheroma, it is important to check for evidence of vascular disease. Renal function can also be affected.

(i) Examination of the optic fundi should be routine in all cases. Retinal vessel changes when present, may reflect presence of degenerative vascular disease. Other fundal changes including presence of haemorrhages and exudates with or without papilloedema are of course only seen in subjects with severe hypertension.

(ii) On heart examination, particular note will be made of any suggestion of left ventricular hypertrophy, murmurs or gallop rhythm. All peripheral pulses should be checked to exclude presence of asymptomatic peripheral vascular disease and neck auscultation is required to check for carotid bruits which would indicate risk for occurrence of cerebral ischaemia.

(iii) Renal status will be assessed by checking for albuminuria or elevation of creatinine readings.

(e) **Assessment :** Disqualifying features on assessment may include:

- Hypertensive retinopathy;
- Renal dysfunction;
- Left ventricular Hypertrophy as indicated by ECG or 2D echo findings;
- Suspicion of coronary artery disease (possibly asymptomatic) on the basis of unexplained ECG changes;
- Suspicion of asymptomatic cerebral or peripheral vascular disease.

(f) SECONDARY HYPERTENSION: In all cases it is necessary to consider the possibility that the hypertension may be secondary. In such a situation the assessment of fitness will have to take account of the primary disorder, which may take precedence regarding fitness for aviation.

(i) It is accepted now that alcohol abuse is the most common cause of secondary hypertension and particular inquiry to exclude such a cause for

blood pressure elevation should be a routine. If an alcohol problem exists a separate detailed assessment is necessary and a **special assessment** is required.

(ii) In some cases hypertension is secondary to some other medical problem such as renal disease, vascular disease of the renal vessels, phaeochromocytoma, primary hyperaldosteronism etc. There will be occasions when the primary disorder can be treated and controlled so that the hypertension resolves. In that setting, periodic serial review may be all that is required. However, unless there are clear guidelines elsewhere in this manual, the AMA should not certify and should consult the PMO.

3.4.6 Treatment of Hypertension

(a) Treatment without Drugs

The most effective non-pharmacological interventions to lower blood pressure are weight reduction, salt restriction, regular moderate exercise and alcohol restriction (less than 3 standard drinks daily). Salt sensitivity is quite variable amongst hypertensives. The elderly and those with more severe hypertension tend to respond best to salt restriction. Even when such interventions are inadequate alone in controlling blood pressure, their use may reduce the need for antihypertensive medication. The most important other non-pharmacological interventions for reducing cardiovascular risk are smoking cessation, reduction in dietary saturated fat and increase in fruit, vegetable and cereal consumption.

CAA looks on these as first options because flying can continue uninterrupted (provided the level of hypertension and its effects do not contraindicate this).

(b) Drug Treatment

CAA has a relatively liberal approach to the use of antihypertensive drugs, provided there is initial "grounding" for an appropriate period (2 to 4 weeks). A period of only 48 hours would be necessary if a diuretic was the only agent prescribed.

(i) THE "GROUND TRIAL": While the risk of developing side-effects on the majority of anti-hypertensives is low the greatest risk of these is in the first two to three weeks following commencement of therapy. For this reason those who have been started on a new anti-hypertensive agent should be grounded for a ***three-week period*** to assess the presence of side-effects, the possibility of over-treatment (i.e. development of hypotensive episodes), renal function and electrolyte balance (particularly with diuretics), and the effectiveness of treatment in successfully lowering the blood pressure.

It is appropriate to start off treatment at a low dose and then to increase it progressively in order to titrate the desired effect against the risk of side-effects or possible over-dosage.

(ii) To encourage progressive introduction of anti-hypertensive drugs into the patient's drug regimen it is considered acceptable to allow a patient to continue flying if drug treatment is increased in dosage. However, if the ***type*** of drug is changed then a further period of unfitness to allow for the development of complications is also necessary.

(c) Unacceptable or Doubtful Drugs

The majority of drugs which are *not* considered acceptable are those older drugs well known to cause major side-effects such as clonidine and methyldopa. Significant side-effects include CNS depression, nasal stuffiness and hypotensive episodes.

Any candidate who is on one of these outdated drugs but has been on this sort of medication for many years showing successful control of blood pressure without significant side-effects may be considered for a *special issuance* whilst still taking this medication. Because the risk of side-effects is related to the dosage of the drug taken there are often limitations on the upper limit of doses of these particular drugs which may be acceptable.

Prazosin, and similar agents, and older drugs such as the ganglion blockers, would not be acceptable under any circumstances.

(d) Preferred drugs

In modern day practice, the drugs most commonly used for the treatment of all grades of hypertension are the calcium channel blockers, ACE inhibitors, Beta blockers and *alpha blockers*. Diuretics are not now favoured as routine first line therapy and beta-blockers appear to be coming less favoured now.

(i) **Beta blockers** are contraindicated in asthma, chronic obstructive airways disease, diabetes peripheral vascular disease and hyperlipidaemia. Some of these agents have ability to cross the blood brain barrier and may cause problems with higher cerebral function such as loss of drive, dreams, difficulty with concentration, fatigue and in some cases an impaired ability to respond to emergencies.

Some authorities, such as the UK, restrict pilots on beta-blockers to flying "as or with a co-pilot" in the first instance and only when it is demonstrated that they can fly safely while on the drug do they allow the candidate to have an unrestricted certificate.

Within New Zealand and Australia the standards are slightly less strict, but it is important carefully to follow up any candidate put on beta-blockers in the recent past, and it may be necessary (with less selective agents) to ensure that there has been no drop-off in mental function as a result of the beta-blocking medication. This may be by having the pilot checked out in a simulator where this is possible and appropriate or by collaborating with the airline check crew or training system.

(ii) **Diuretics** are contraindicated or should be used with caution in patients with diabetes, gout or hyperlipidaemia. They can also induce hypokalaemia.

(iii) **ACE inhibitors** have a favourable profile particularly in the younger patients and those with diabetes, gout, renal disease or hyperlipidaemia. It is important that diuretics be discontinued for 7 days prior to commencing treatment with ACE inhibitors, since this combination may induce very profound hypotension which is usually associated with symptoms and sometimes collapse

(iv) **Calcium antagonists** are useful in the elderly and also in patients with airways disease, peripheral vascular disease or in those with hyperlipidaemia.

(v) **Alpha blockers** are particularly used in males with a history of prostatic obstruction.

(vi) To quote from the recent review on the management of hypertension in New Zealand published in the NZMJ 28 June 1996: "Tailoring drug therapy to the individual patient is the cornerstone of rational therapeutics. The field of hypertension lends itself to this approach".

3.4.7 Hypertension Surveillance

(a) The applicant who remains on treatment will be required to undergo annual medical examination including the completion of the *CAA24067/214 Blood Pressure* form by the DME or a specialist physician at the discretion of the Medical Assessor responsible.

(b) Completion of this form for surveillance purposes should be accompanied by the following:

(i) An annual ECG.

(ii) An annual serum creatinine, uric acid and cholesterol and lipid profile.

(iii) An annual serum potassium and glucose, if the applicant is on a diuretic.

(iv) Annual spirometry if the applicant is on a beta-blocker.

(v) Periodic 2D echo studies if such were previously abnormal.

(c) ***ASSESSMENT:*** *Where subsequent medical reports indicate unsatisfactory control of the blood pressure, the AMA should review the cardiac risk factors and decide whether these exceed a level the AMA is authorised to certify. If the risk is excessive, a TUF assessment should be made while treatment is brought under control. Otherwise, as before, the applicant may be certified FIT while treatment is adjusted.*

Appendix A – Notes for DMEs on Taking an ECG

[DME,AMA]

General

There is a wide variation in the quality of ECGs presented for assessment. In all fairness, it must be admitted that many doctors send consistently good tracings clearly identified and mounted correctly. But unfortunately there are a minority whose efforts can be graded from "badly taken, but just readable" to "impossible to interpret reliably". It is often difficult to believe that these tracings have been checked by the doctor, and we can only assume that the whole procedure has been entrusted to someone with little or no training in taking ECGs.

At CAA we don't like rejecting ECGs because of poor recording or presentation. Writing the letter is a nuisance to us, and it must be annoying for you to receive it, not to mention the considerable inconvenience to the pilot. Nevertheless, the only satisfactory way to avoid these problems in the long term is to prevent them. It is false economy and an unacceptable practice for an AMA to accept poor results "just this once", and could put the AMA in the position of accepting legal accountability for the poor quality control of a colleague.

We therefore present these notes to assist DMEs and AMAs to improve the quality of ECGs. This should be to everyone's benefit.

Common Faults in ECGs

The most common faults in taking an ECG are somatic tremor, 50 cycle a/c interference, wandering baseline, incorrect standardisation and transposition of the right and left arm leads. With a little care these mistakes and artefacts can be avoided, and it would be fair to say that the secret of taking a good ECG can be summed up in three words – attention to detail.

Preparing the Patient for the Electrocardiogram

Perhaps the most important detail to remember, and one which is often completely ignored, is that **it is almost impossible to take a good electrocardiogram on a patient who is not relaxed**. Relaxation means comfort, warmth, and reassurance and can only be achieved if these three criteria are fulfilled.

Comfort: This requires a well padded couch which should be wide enough to allow both arms to lie by the sides and, at the very least, there should be a blanket between the patient and the cold vinyl. The pillow should be soft, and the head and shoulders slightly raised as most patients seem to prefer this to lying flat.

Warmth: The room should be at a comfortable temperature of about 18°C and a hot-water-bottle or even an electric under-blanket can be useful. Don't forget, however, to switch off the latter when taking the tracing to avoid a/c interference. Even if these measures are used the patient must **always** be covered with a blanket. Apart from preserving female modesty it is remarkable how this will eliminate somatic tremor even in a patient who denies feeling cold.

Reassurance: Anxiety is a common cause both of somatic tremor and a wandering baseline, so no electrocardiogram should ever be taken before the nature of the procedure has been clearly and sympathetically explained.

Points which should always be emphasised are:

(a) The test is completely harmless.

(b) The machine merely takes a recording of the heart beat.

(c) There will be no electric shocks.

(d) There will be absolutely no discomfort.

It is difficult to take a satisfactory ECG if the patient is talking, but a garrulous patient is often an anxious one and the above measures may also solve this problem. If not, a tactful suggestion that quietness is essential may be necessary.

When you are satisfied that the patient is physically and psychologically relaxed, but only then, should you go ahead with the preparations for taking an electrocardiogram.

Preparing to take the Electrocardiogram

Before going any further make quite sure that all the electrodes and the patient-cable connections are scrupulously clean. If this is neglected poor contact will occur with resulting a/c interference and wandering baseline.

For the same reason the skin should be carefully prepared by rubbing in a small amount of electrode paste with a wooden spatula, using just enough pressure to cause slight erythema. The electrodes are then applied with a circular motion in order to make good contact. A plump non-bony area of the skin should be chosen. The inner aspect of and forearms and the outer aspect of the calves are usually the most suitable sites.

The tension of the straps is also fairly critical. It must be just enough to hold the electrodes firmly in place, but without causing any discomfort. If electrode pads are used instead of paste make sure that they are moist, and as before use a slight rubbing motion with the electrode before fixing it in position.

Pay particular attention to **the right-leg electrode** as this is the **earth lead**, and a poor connection here is certain to cause a/c interference. If the a/c interference persists make sure that the fault does not lie in the earth wire of your three-pin plug, or in the wall plug itself.

Hairy chests can be a problem when applying the suction electrode but shaving should **never** be necessary. The secret lies in using lots of paste and rubbing it well in, so that it penetrates

to the underlying skin. If the electrode is then applied with a firm twisting motion it can almost always be made to stick.

It is very important that there should be no drag on the electrodes, and the best way to avoid this is to support the cable by laying it on the patient and checking each wire for the absence of tension. This also applies to the suction electrodes when taking the chest leads.

Finally, **check the electrodes to ensure they are connected to the correct limbs**. Transposition of the right and left arm leads is a very common mistake, but should be recognised immediately by the fact that **in lead 1 the P-wave, QRS complex, and T-wave are all upside down**. If by any chance the connections are correct, then you have just made a diagnosis of dextrocardia.

Taking the electrocardiogram

Standardisation: This should be performed as a routine at the beginning of every electrocardiogram. The deflection should always be adjusted to 10 mm (normal standardisation) unless there is a very good reason for doing otherwise. **Half standardisation is rarely, if ever, necessary**. It never helps in interpretation, and no harm can be done avoiding it completely.

Ideally the standardisation signal should have an overshoot of ½ mm (but never more) at the top of the initial deflection. This is an indication that the stylus pressure and damping are correct and that the high frequency response is optimal. Overshoot is not essential however, but at least the stylus pressure should be adjusted so that the top of the signal is rectangular and not sloping upwards.

The main reason for standardisation, of course, is to be able to compare subsequent tracings from the same patient. It is also important for the calculation of QRS complex voltages, and on these ground alone it should never be omitted.

Paper speed: With many machines it is possible to vary the paper speed from the normal of 25 mm/sec to 50 mm/sec. This has the effect of 'stretching out' all the complexes and intervals to twice their normal width. The idea behind this option, presumably, is to aid in the diagnosis of tachyarrhythmias.

In practice, however, it is of no real help. In fact, if it is inadvertently left switched on, one can get a pattern in an otherwise normal electrocardiogram which bears a superficial resemblance to profound sinus bradycardia, with first degree heart block, and bundle branch block. To avoid this situation, it is best to immobilise the switch.

Recording the twelve leads: It is important to ensure that the baseline is adjusted so that the full QRS complex is recorded at the standard voltage. This will often involve lowering the baseline when recording the precordial leads. As the notes in section 3.2.3 stress, ECGs recorded at "half standardisation" are not acceptable. The automation in some ECG machines that record in that way to fit complexes onto a narrow strip will have to be "over-ridden" to obtain an acceptable record.

While taking the chest leads the patient should be encouraged to breathe quietly and naturally. But if despite this the baseline wanders, he or she should be asked to stop breathing for a few seconds during each recording.

Summary of Mistakes and Artefacts and their Remedies

Somatic tremor: Make sure that the room is warm and that the examination couch is comfortable. Always throw a blanket over the patient. Reassure the patient about the nature of the test and get him or her to shift into a more comfortable position to relax any remaining muscle tension. If all else fails try suction electrodes attached to the shoulders or hips.

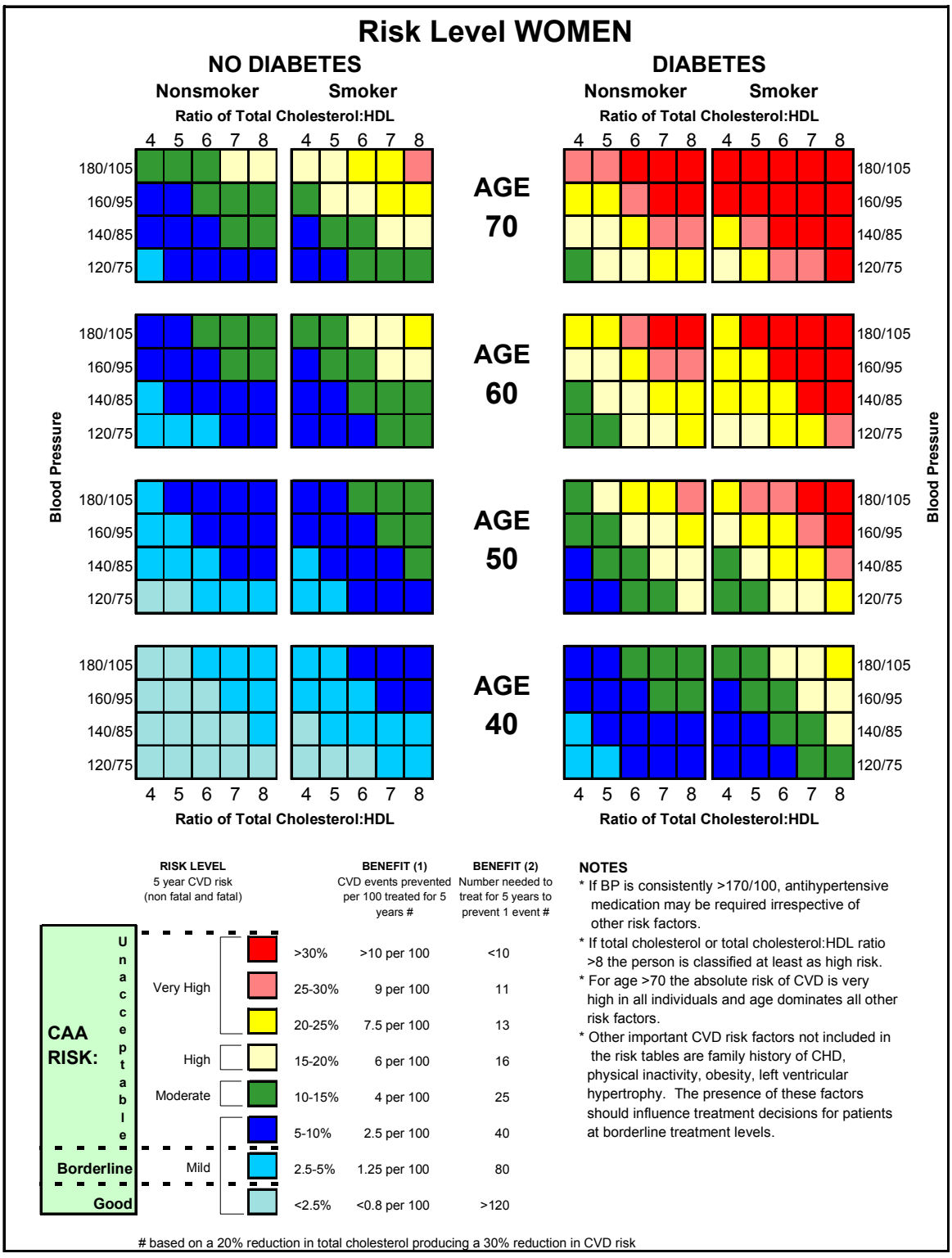
Wandering baseline: Clean the electrodes and their connections thoroughly. Prepare the skin correctly. Make sure the straps are firm but not too tight. Examine each electrode for 'drag' from the cable leads. Movement of the patient will cause the baseline to wander and suggests anxiety and/or discomfort. When taking the chest leads don't forget, if necessary, to ask the patient to stop breathing momentarily during each recording.

50 cycle a/c interference: Are the patient and the machine properly earthed? Examine all the electrode connections, particularly the right leg. Check the plug connections. Is the electric blanket turned off? Try moving the patient cable to a different position and make sure that it is not near the 230 volt power cord.

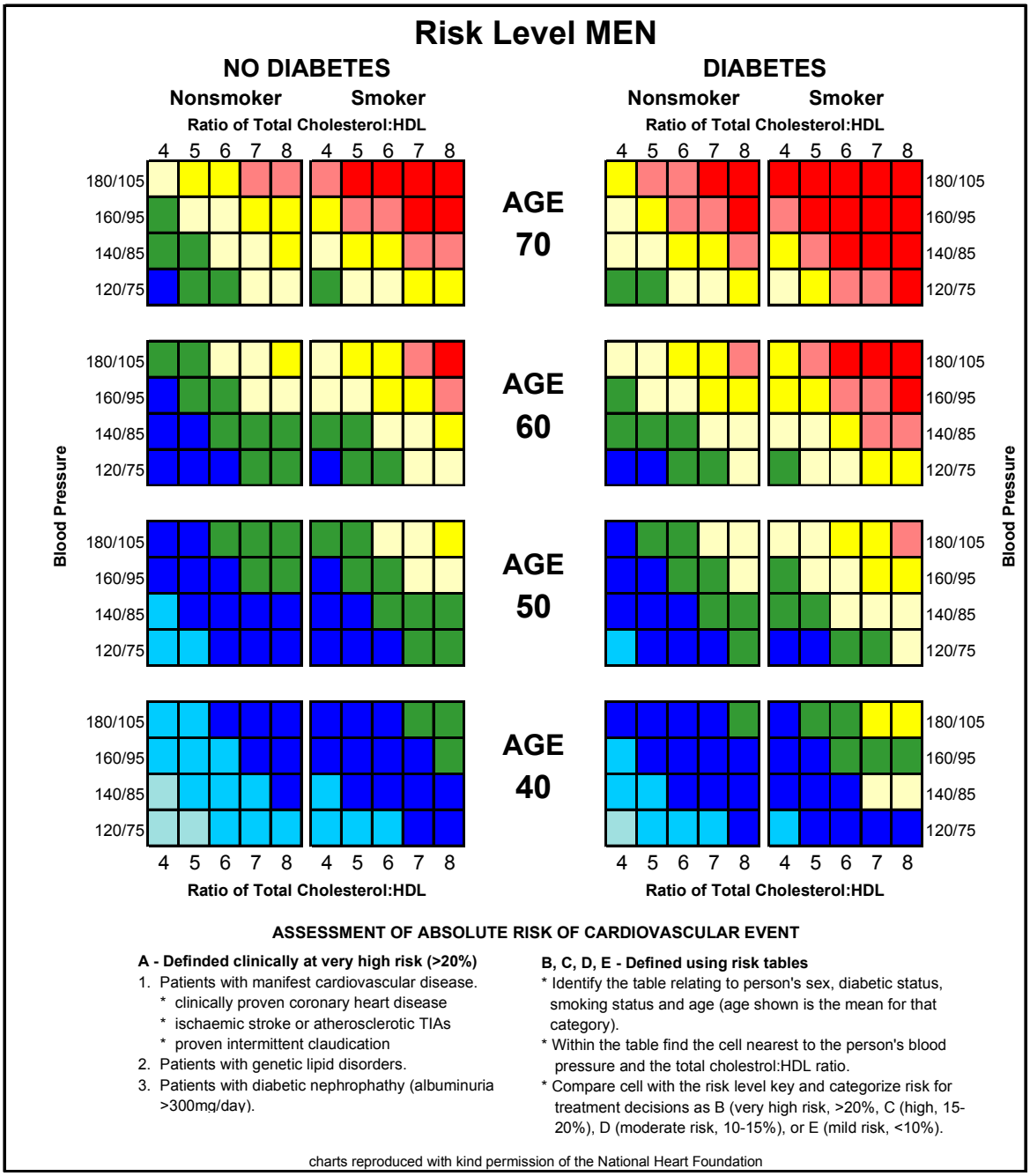
Transposition of the limb leads: Is lead 1 "upside down"? Always check the leads before starting to take the tracing.

Incorrect standardisation: Don't use half-voltage standardisation.

Appendix B – Assessing Risk for a Cardiovascular Event



NB: *Care is needed with this method. It looks at 5-year risk, and the terms "moderate" & "mild" risk may give a misleading impression for civil aviation.*
*The three "Mild" colour-codes represent the boundaries of CAA's risk categories -- only those below 2.5% per 5 years fit CAA's "**good**" range; the top "**Mild**" category (5 - 10 % per 5 yrs) is within CAA's "**unacceptable**" range; those in between require care - See 3.1.2.*



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