FSG 600-02
AIRCREW WITH KNOWN CORONARY ARTERY DISEASE

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C. Davenport ED, Syburra T, Gray G et al. Management of established coronary artery disease in aircrew with previous myocardial infarction or revascularization. HEART 2019, 105 Suppl 1, p S31-37
D. FSG 600-01 Aircrew Cardiovascular Risk Screening.

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BACKGROUND

1. Cardiovascular disease, and particularly coronary artery disease (CAD), remains a common cause for medical loss of trained CAF aircrew resources. In the past, with the diagnosis of coronary heart disease, aircrew were considered unfit for aircrew duties, and generally were found unfit for CAF service. Advances in interventional techniques and secondary prevention have resulted in a significant improvement in immediate survival and long-term prognosis. This has resulted in a review of the aeromedical disposition of aircrew with coronary heart disease, and after careful risk analysis, a return to at least limited flying duties for those aircrew assessed as being at acceptably low risk.

2. The purpose of this Guideline is to outline the assessment of aircrew with known coronary heart disease to appropriately assess risk and hence aeromedical disposition.

CORONARY ATHEROSCLEROSIS AND CORONARY EVENTS

3. Coronary atherosclerosis develops as a result of endothelial injury caused by various factors including dyslipidemia, hypertension, cigarette smoke exposure, inflammation and other coronary risk factors. Progressive injury results in endothelial and intimal damage, leading to an inflammatory response with the accumulation of lipids and macrophages in the vessel wall. The resulting lesion may mature and calcify, but can also undergo plaque rupture resulting in intravascular thrombus formation with vessel obstruction causing acute coronary syndromes including myocardial infarction. Many acute coronary syndromes result from plaque rupture events in non-flow limiting lesions. Alternatively, progressive growth of plaque can lead to flow limitation when cross-sectional luminal diameter is narrowed beyond 70%, resulting in more chronic ischemic syndromes including angina, and silent ischemia. In some aircrew, an additional consideration is exposure to +Gz which may exacerbate ischemia.

4. Death in acute coronary syndromes is generally the result of an arrhythmic event, or severe myocardial damage with inadequate pump function. In the aircrew population, the initial presentation of coronary atherosclerosis is often an acute plaque-rupture event, and concurrent arrhythmic death in up to 25%. In-hospital survival has been greatly improved by interventions including thrombolysis and acute revascularization with percutaneous coronary interventions (PCI).

5. Long-term survival after an acute coronary event depends primarily on remaining ventricular function, plaque burden, residual ischemia, and control of risk factors. Interventions leading to flow improvement (PCI and coronary artery bypass grafting – CABG), are generally palliative procedures which, apart from a few specific circumstances such as left main disease, do not significantly improve prognosis. Control of risk factors resulting in amelioration of the underlying disease process (i.e. coronary atherosclerosis) has the biggest influence on long-term survival. Previous randomized controlled trials have demonstrated a significant effect in secondary prevention with lipid lowering, and more recent trials have shown further risk modification with intensive lowering of LDL cholesterol, to levels below 2.0 mmol/L.

DEFINING RISK IN CORONARY DISEASE

6. Coronary disease may be found on screening asymptomatic aircrew with elevated risk factors (Ref D), or after a coronary event. Risk estimation for a (recurrent) coronary event is based on

a. the overall plaque burden (derived from CT coronary calcium scores, and/or angiography, either CT coronary angiography- CTCA, or invasive -ICA),

b. the hemodynamic significance of coronary lesions, based on angiographic findings and stress testing for inducible ischemia

c. control of risk factors

7. Defining Plaque Burden- CT Coronary Calcium Scores

FSG 600-01 specifies that aircrew identified as being at high estimated risk should undergo a CT coronary artery calcium score (CACS). Any score greater than zero indicates the presence of coronary plaque, with plaque burden increasing with increasing CACS. Calcified plaques are usually stable and are unlikely to rupture, but rather cause symptoms due to flow limitation. Table I shows annual risk for a coronary event (revascularization, MI – myocardial infarction, or SCD –sudden cardiac death) based on the CACS.

CACS	0	1-9	10-99	100-399	400-1000	>1000
Annual event rate (%)	0.45	0	1.11	1.14	3.00	4.01

Table I: Coronary events (revascularization, MI, SCD) with CACS

Table 2 shows indicates the recommended actions for aircrew based on CACS

CACS SCORE	Risk for an event	DISPOSITION
1-99	Low	Risk factor modification Consider medication (eg statin)
100-400	Moderate.	CT coronary angiogram (CTCA) or ICA Exercise stress test with imaging Intensive risk modification. Smoking cessation mandatory Medication to target LDL < 2.0, TGs < 1.5
>400	High	Invasive coronary angiogram (ICA) Stress test with imaging Intensive risk modification Medication to target LDL <1.4

8. Coronary Angiography/Plaque burden and hemodynamics

Coronary angiography, either via CTCA or ICA defines the coronary artery lumen. Cardiologists define lesions greater than 50% luminal narrowing as obstructive, and greater than 70% as hemodynamically significant. The hemodynamics of coronary lesions can further be clarified by fractional flow reserve (FFR), a technique which measures the pressure drop across a lesion. FFRs < 80% are considered hemodynamically significant. When possible, obstructive lesions in aircrew undergoing angiography should be assessed with FFR. Aircrew with a hemodynamically significant stenosis require revascularization to return to flight regardless of symptomatology. Left mainstem coronary lesions are higher risk and aeromedically, a LMS stenosis >30% is considered as obstructive disease

9. Coronary angiography also identifies the plaque burden. The USAF followed a cohort of ~1500 aviators with angiographically identified coronary disease. The best predictor of coronary events was found to be the aggregate (sum of all angiographically identified lesions), and the presence of a hemodynamically significant lesion. Using aggregate scores and maximum lesion, the USAF classification is:

a. Minimal CAD (MinCAD) - aggregate less than 50%, and no single lesion greater than 50%;

b. Moderate CAD (ModCad) - aggregate >50% or greater but < 120%, with no single lesion greater than 70%; and no more than one lesion >50%

c. Significant CAD (SCAD) – any single lesion greater than 70%, any left main lesion > 50%, aggregate greater than 120%

Table 3 shows the annual event rates for MI, SCD and revascularization based on the above angiographic classification at 2, 5 and 10 years post-angiography

Angiogram	2yr	5yr	10yr
Normal	0	0	0.1
MCAD	0.6	0.4	0.9
ModCAD	1.2	2.4	2.3
SCAD	6.3	3.3	2.9

In the USAF, aviators with MinCAD are returned to FCIIA duties (i.e. non-fast jets) with a requirement for annual evaluation to include exercise stress testing with imagine (stress echo or myocardial perfusion imaging) on alternate years. With ModCAD flying duties are limited to FCIIC (i.e. non fast-jet, with another qualified pilot), with a requirement for annual evaluation with myocardial perfusion imaging (MPI) demonstrating no ischemia and repeat catheterization every three years. SCAD is disqualifying for flight duties. Risk factor modification is a requirement for return to duties with any degree of coronary disease.

10. **Tests for Inducible Ischemia/hemodynamics**

Stress tests with exercise or pharmacological agents (eg dobutamine), generally with imaging (nuclear perfusion imaging, stress echo, or PET) are used to assess for inducible ischemia. These tests do not identify non-flow limiting lesions (ie <70% lesion or FFR >0.8). Aircrew with angiographically identified obstructive coronary disease should undergo stress testing. In addition to assessing for ischemia, exercise stress testing provides additional information helpful for assessing risk including aerobic capacity and arrhythmia assessment. A negative maximum exercise stress imaging study provides an independent indicator for assessing risk for a future coronary event, with a negative maximal effort exercise stress imaging test conferring low risk.

CORONARY REVASCULARIZATION PROCEDURES

11. Reviews of both PCI and CABG procedures in civilian and military populations have demonstrated subsets with annual event rates (i.e. death, acute MI) in the range of 1-3% per year, with higher event rates of 2-8% when repeat revascularization procedures are included. For example, the large COURAGE trial reported a death rate of 1.7% per year and MI rate of 2.9% per year over 4.6 years of follow-up in a population with mean age 61, of whom one third were diabetic, two thirds hypertensive, and 20% smokers. Although there is a perception that revascularization procedures “fix” the problem of obstructive coronary disease, long-term follow-up data demonstrates that they are palliative and not curative, with no significant differences in event rates between intensive medical therapy and revascularization procedures in most cases. Following revascularization, event rates for death and MI are comparable for PCI and CABG, with a trend usually favouring CABG, especially with internal thoracic arteries, which have a significant advantage over saphenous vein grafts with patency rates over 90% at 10+ years. Revascularization rates are lower with CABG versus PCI, and with stent versus simple angioplasty. Drug-eluting stents have lower early re-stenosis rates than bare metal stents, but have an increased incidence of late in-stent thrombosis. This has been ameliorated by long-term use of anti-platelet agents such clopidogrel and ASA which may need to be continued for 12 months or beyond.

MYOCARDIAL INFARCTION

12. In individuals who have an acute ischemic event related to coronary atherosclerosis, long term prognosis is related primarily to the extent of myocardial

damage, as determined by ejection fraction, as well as the coronary atherosclerosis burden. For those with minimal or modest damage, with well-preserved ventricular function, prognosis is similar to individuals with stable coronary disease. More extensive myocardial damage, with compromised ventricular function, increases risk for arrhythmias, heart failure and recurrent events. With well-preserved ventricular function, prognosis is related to the risk for a recurrent event, as manifested by the extent of coronary disease, presence or absence of stress ischemia, and control of risk factors. Irritability at the infarct site causing arrhythmias also affects prognosis.

AEROMEDICAL DISPOSITION

Disposition for Coronary Disease Not Requiring Revascularization

13. Aircrew who are discovered to have coronary disease, through investigation of asymptomatic individuals at high risk, or after developing symptoms, should receive standard-of-care intervention. The decision to undertake revascularization interventions (e.g. PCI or CABG) should be made on clinical grounds, with the caveat that aircrew with hemodynamically significant disease require revascularization to remain on flying duties. Once fully clinically stable, and no sooner than six months, aircrew can be risk assessed to determine medical suitability for return to flight duties. The following dispositions apply (with the requirement for risk factor control – see below)

a. MinCad on angiography and/or CACS>100 <400

(1) Pilot aircrew may be returned to restricted flying duties, A3 - Unfit Harvard II, Tutor, Hawk, CF-18;

(2) All other aircrew may be returned to unrestricted aircrew duties.

b. ModCad on angiography and/or CACS>400

(1) Pilot aircrew may be returned to restricted flying duties, A3 - To fly with or as copilot, unfit rotary wing aircraft, unfit Harvard II, Tutor, Hawk, CF-18

(2) All other aircrew may be returned to unrestricted aircrew duties

c. SCAD on angiography or hemodynamically significant disease- unfit aircrew duties

Note: For CACS<100 or luminal irregularities on coronary angiography, no operational restrictions are required.

Disposition following Revascularization Procedures

14. Procedures include PCI (percutaneous coronary intervention) and CABG (coronary artery bypass grafting).

a. Aircrew who undergo a revascularization procedure (PCI or CABG) may be assessed for a return to flight duties a minimum of six months after the procedure. Results of a current CT coronary angiogram or clinical angiography is required detailing the status of the revascularization intervention, as well as residual/other coronary plaque lesions.

b. Aircrew must be assessed for exercise-induced ischemia with exercise myocardial perfusion imaging (MPI- including PET) or stress echo. A stress MPI or stress echo demonstrating ischemia is disqualifying for a return to flight duties.

c. Provided the revascularization procedure remains successful, and there is no evidence of stress induced ischemia, aeromedical disposition follows the recommendations in para 13

Disposition Following Myocardial Infarction

15. Aircrew who sustain myocardial damage (i.e. myocardial infarction) will require additional evaluation to assess ventricular function and propensity for arrhythmias.

a. Aircrew may be evaluated at least six months following myocardial infarction.

b. In addition to the requirements listed above for return to flight duties following revascularization, the assessment must include:

(1) Assessment of ventricular function with either nuclear imaging (MUGA) or stress echo, at rest, and following maximum effort stress testing. Resting ejection fraction must be equal to or greater than 50%, and exercise ejection fraction must be greater than resting.

(2) Exercise stress testing for arrhythmias. This may be combined with the stress echo or MUGA.

(3) Ambulatory cardiac monitoring- 24 hrs minimum

c. For aircrew who demonstrate (near) normal ventricular function and absence of significant arrhythmias, aeromedical disposition is based on para 13.

d. For aircrew with more severe myocardial damage following myocardial infarction, AUMB disposition will be on a case-by-case basis based on an evidence-based risk assessment.

Risk Factor Control

16. In order to be considered for a return to flight duties, aircrew with known coronary disease must have all modifiable risk factors controlled, that is:

a. Smoking – cessation is a requirement for return to flight duties.

b. Lipids – must be controlled to secondary prevention targets. Dietary modification is a cornerstone of dyslipidemia management, and appropriate dietary advice should be provided for management of weight, and to optimize lipids. In general, unless not tolerated, aircrew with identified coronary artery disease should be placed on a statin as a minimum. Other drugs including ezetimibe, ecosapent, and PCSK9 inhibitors may be used if clinically indicated.

(4) LDL target is < 1.8, optimal <1.4

(5) Apo B target is < 0.85 g/L

(6) Total/HDL ratio target is < 4.0

(7) Fasting triglycerides < 1.5

c. HS-CRP – should be assessed and treated using statins if required.

(1) HS-CRP target is < 2, optimal is < 1

d. Dysglycemia/Metabolic Syndrome – dysglycemia (IFG, IGT or DM) must be controlled, using medications if required.

(1) Hemoglobin A1C < 7.0

(2) Metabolic syndrome diagnosis is disqualifying for aircrew with known coronary disease.

e. Blood Pressure – hypertension should be controlled, using medications as required. FSG 1900-01 *Medications and Aircrew* details the recommended and approved medications.

(1) Target blood pressure is < 130 systolic and < 85 diastolic

(2) Preferred first line medications include ACE inhibitors, ARBs and thiazides. Second line medications include calcium channel blockers and beta-blockers (beta blockers require an operational flying restriction for pilots)

Requirement for Follow-Up

17. Aircrew returned to flying duties with known coronary artery disease are required to have:

a. Annual cardiologic follow-up to include clinical assessment, full risk factor evaluation, and maximum effort treadmill stress testing, preferably with myocardial perfusion imaging or stress echo.

b. Ongoing demonstration of control of all modifiable risk factors.

c. Coronary angiography with CT or invasive angiography every five years.

Medical Employment Limitations

18. With the above requirements for follow-up, aircrew will generally be assigned *G3 – Requires medical follow-up at intervals greater than six months, with annual specialist follow-up*. An occupational restriction would generally not be required for aircrew, except as reflected in the Air Factor. Aircrew with coronary artery disease will also require review by DMedPol.