Coronary Artery Disease in Aircrew
What to do next?

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Eddie D. Davenport, M.D., F.A.C.C
Lt Col, USAF, MC, FS
Chief Cardiologist, Aeromedical Consultation Service
Assistant Professor of Medicine, Wright State University, OH

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NATO Aviation Cardiology Working Group (RTG HFM-251)

Eddie D. Davenport, M.D., F.A.C.C
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Chief Cardiologist, Aeromedical Consultation Service
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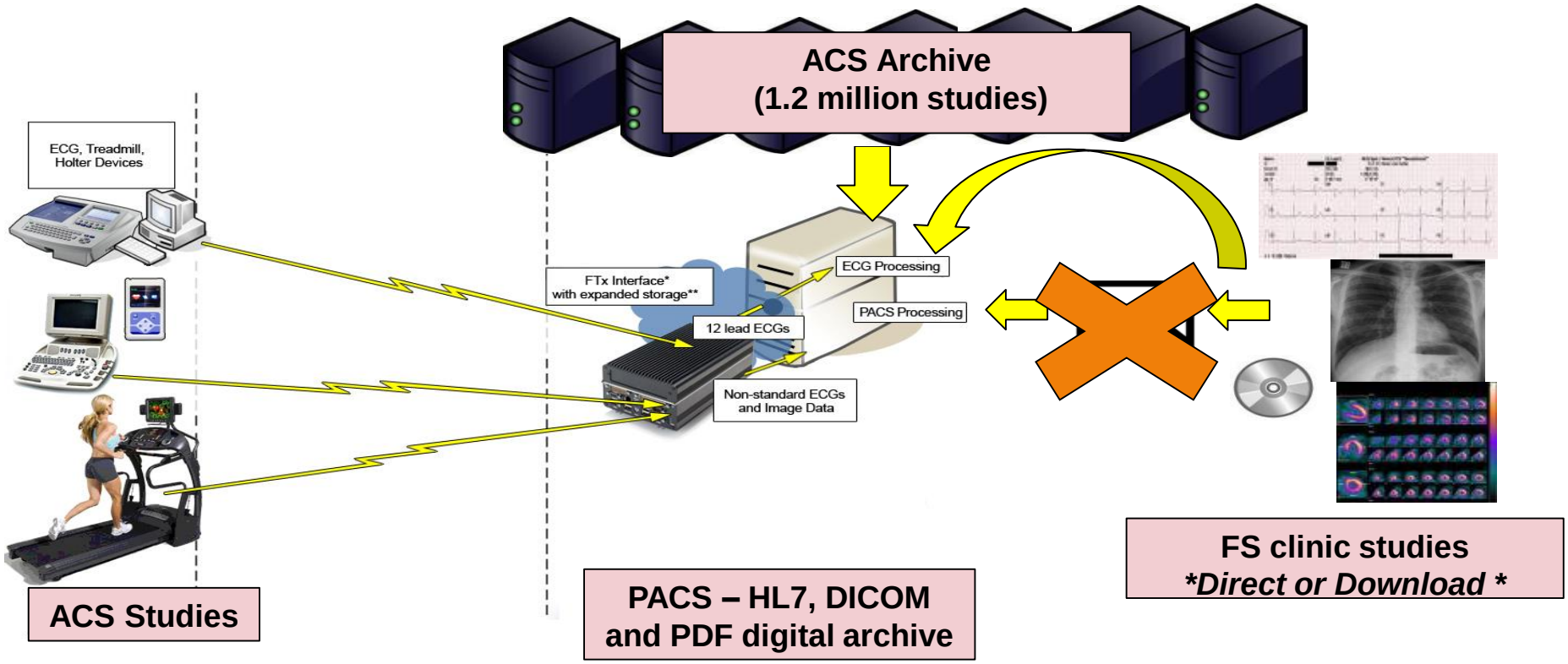
Disclosure Statement

- **The views expressed are those of the author and do not necessarily reflect the views of the United States Air Force or the United States Government.**

- **I have no relevant financial relationships to industry.**

USAFSAM Cardiology



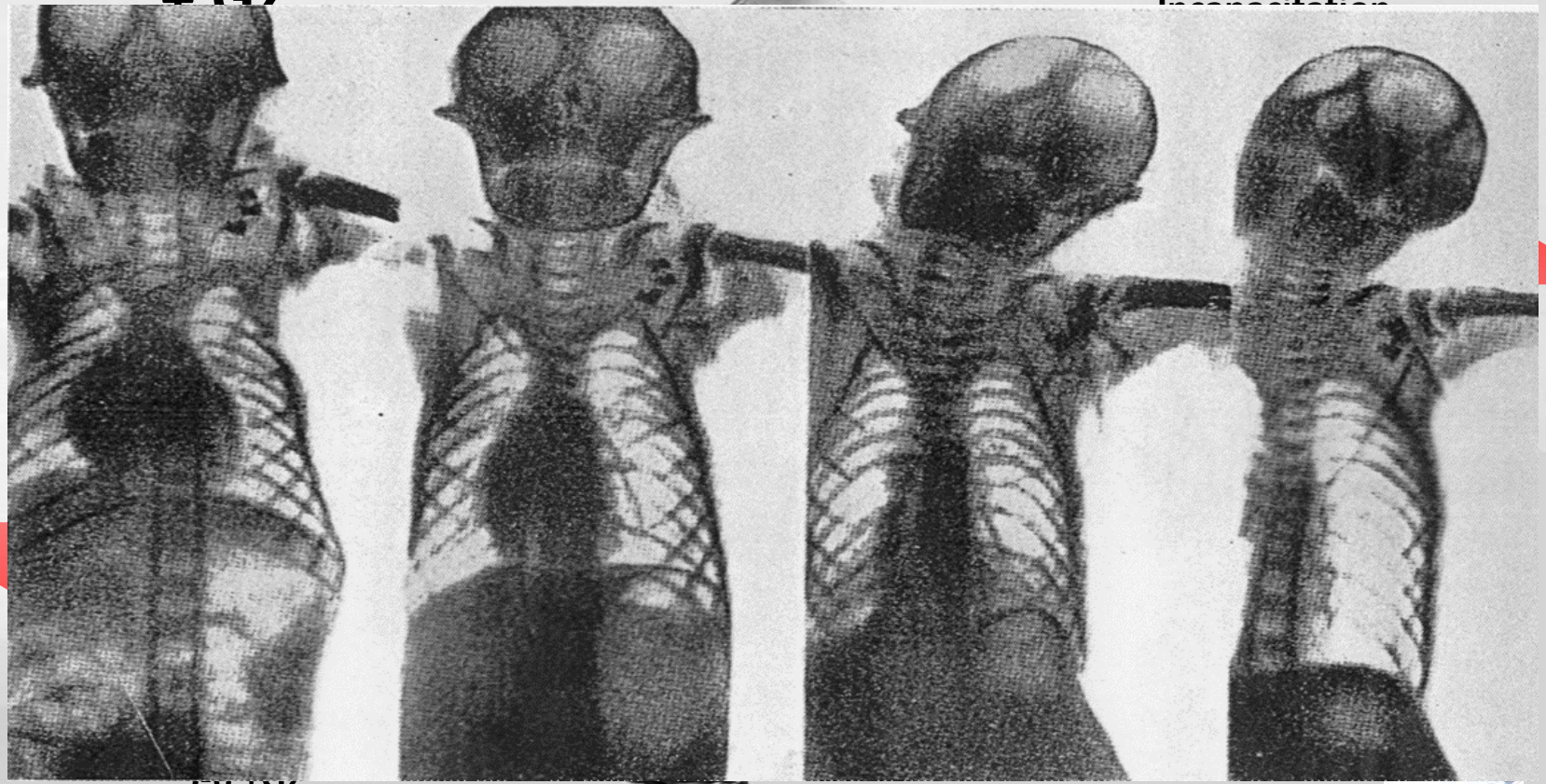
ECG Library Archive Database

- **Since the 1950s the library annually receives, interprets, and databases**
  - 25,000 ECGs, 250 echocardiograms, 250 treadmills, 175 Holter monitors
  - Numerous CT/MRIs and catheterizations
  - 100% digitized as of 1 Jan 2012!
  - Electronic submission at >200 sites throughout the world.

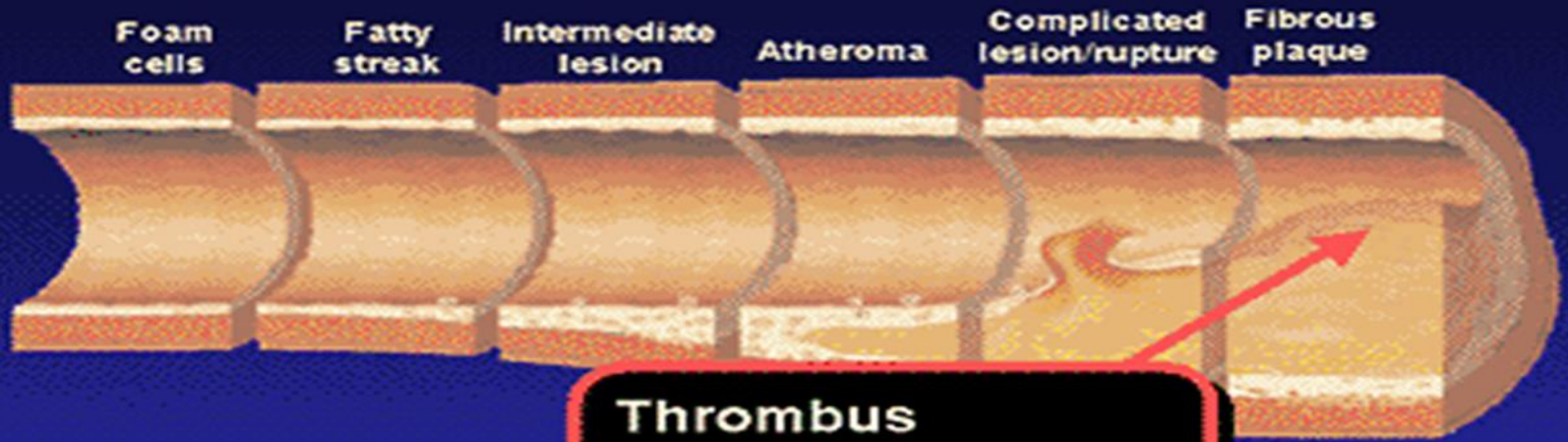
- **Aeromedical disposition and waiver policy**
  - 60 yr of aviator data for a specific population
    - 1.3 million studies on 293,000 aircrew, 1957-2017, followed into retirement, ages 17-93
  - Outcomes data and policy changes almost monthly = USAF Waiver Guide

NEW!!! NATO Working Group Consensus documents

Cardiovascular Effects



Atherosclerosis Timeline



Adapted from Pepine CJ. *Am J Cardiol.* 1998;82(suppl 10A):23S-27S.

I got screened…and CATHED!

but I'm asymptomatic…

- 1487 male aviators
  - Mean age 43 yr, follow-up 14 yr
- 929 NML, 249 mild CAD (10%-50%), 124 moderate CAD (50%-70%), and 185 severe CAD (>70%)
- Average annual event rates at 2, 5, 10, and 15 yr for:
  - Cardiac death, first nonfatal MI, or first delayed coronary revascularization

Source: USAF ECG Library Database: Analysis Natural History CAD

Multivariate Analysis for Annual Event Rates: Single stenosis

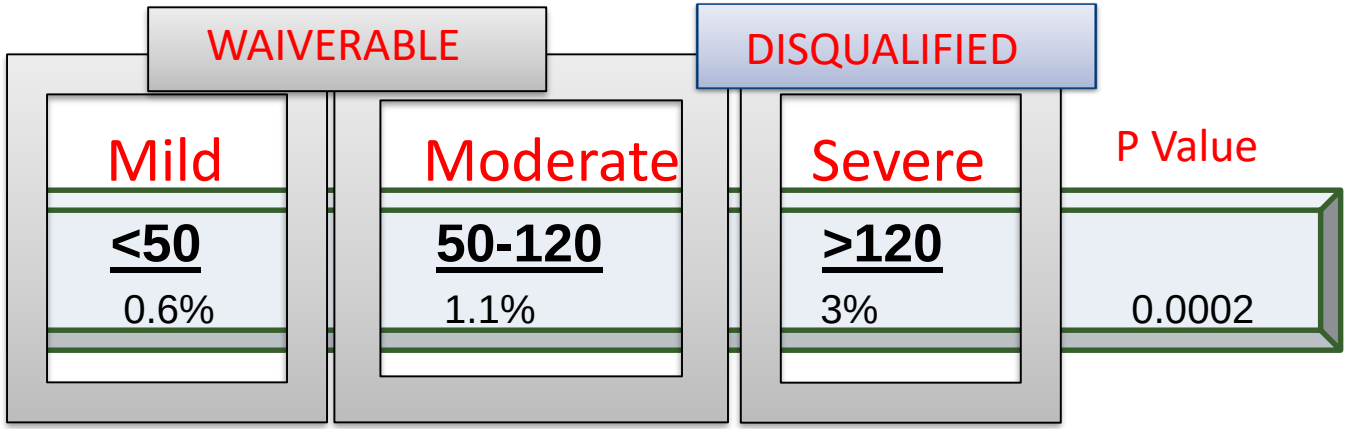
• **Left Main** *(single stenosis)*	**>50%**	**30-49%** 1-2.1%	**10-29%** 0.5-1%	
• **LAD/LCX/RCA** (single stenosis)	**>70%**	**50-69%** 1.0-2.2%	**30-49%** 0.8%	
• **Aggregate**	**<50** 0.6%	**50-120** 1.1%	**>120**	**p value** 0.0002

NATO Working Group

	Stenosis	FFR	Aircrew disposition
Hemodynamically Significant	≥70%	< 0.8	Grounded*
Single Vessel Obstructive (non hemodynamically significant)	50-69%	>0.8	With restrictions**^
Single Vessel Non obstructive	30-49%	>0.8	With restrictions**
Luminal Irrégularités	Up to 30%	>0.8	Unrestricted possible**
Aggregate Stenosis – Severe	≥120% = Severe	N/A	Grounded*
Aggregate Stenosis - Moderate	50-119%	N/A	With restrictions**
Aggregate Stenosis - Mild	< 50%	N/A	Unrestricted possible**
Left Main Stenosis – significant	30-49%	N/A	With restrictions**^
Left Main Stenosis	≥50%	N/A	Grounded*

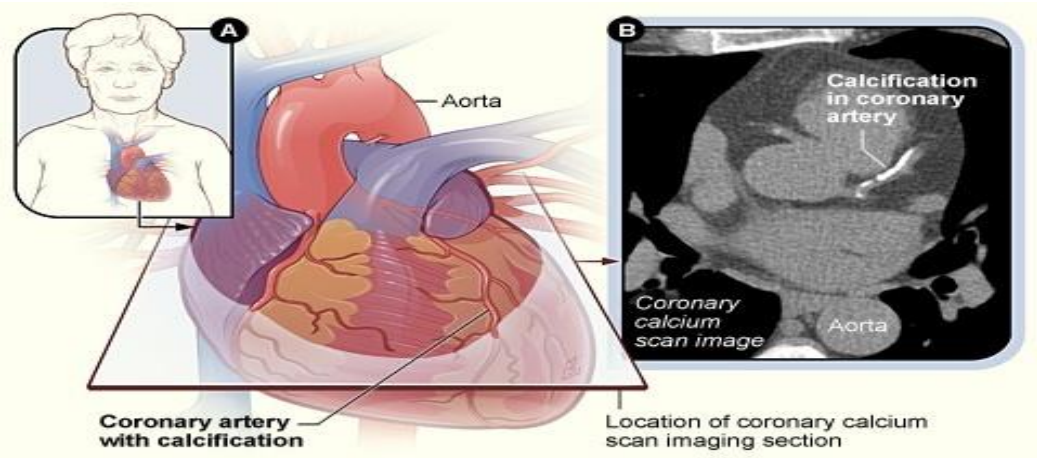
Aircrew with hemodynamically significant stenosis with associated ischemia require revascularization (CABG or PCI) regardless of symptomatology to return to flight .	**Class I**
Aircrew with more than one 50% stenosis are not recommended to return to flight .	**Class I**
Aircrew with obstructive, single vessel CAD, without ischemia, and not deemed hemodynamically significant should be returned to restricted flight duties with aggressive risk factor modification and close follow-up.	Class IIb
Aircrew with any lesion 30-49% should be restricted to non-high performance aircraft. For pilots no further restrictions are required	**Class I**
Aircrew with 30-49% left main or proximal LAD stenosis should be treated as obstructive disease with flight restrictions.	Class I
Aircrew with ≥ 50% aggregate stenosis should be limited to non-high performance aircraft. Pilots should further be restricted to dual pilot operations.	**Class I**

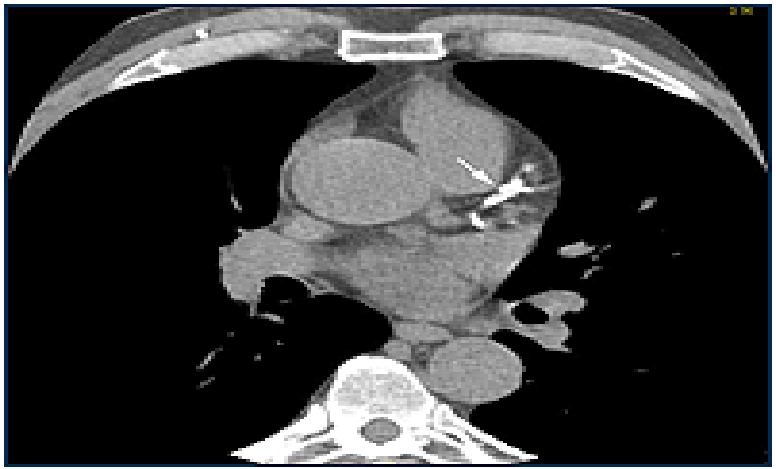
CAD in Aviators is DEFINED BY ANATOMY



Coronary Calcium	Negative	Positive	*p-value*
	0.66 %	1.8%	0.006

Detection of Coronary Artery Calcium by Computed Tomography





<u>Calcium scoring simply "adds up" the amount of coronary calcium present on the CT: the more calcium, the higher the score</u>.

Comparison of Event Rates

Angiography Summed Score

- Min CAD (aggregate < 50%):
  - ***0.5% to 1.0%/yr***
  - Annual Re-eval
- Mod CAD (aggregate 50-120, no lesion > 70):
  - ***1.0% to 2.0%/yr***
  - Annual Re-eval; cath q **5 yr (NEW)**
- Sev CAD (aggregate > 120 or lesion > 70):
  - ***3.0% +/yr***; *DQ – no waiver*

CAC Score (literature)

- CAC 0-9: **0.00 %/yr**
- CAC 10-100: **0.5% to 1.0%/yr**
- CAC 101-399: **1.0% to 2.0 %/yr**
- CAC >400: **3.00%/yr and up**

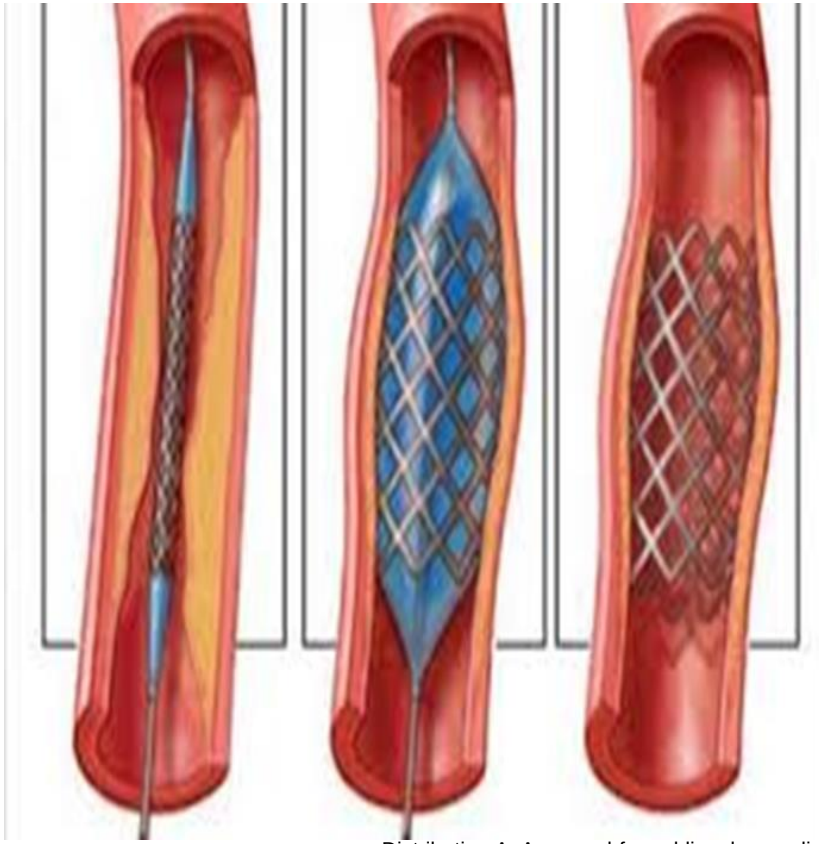
Said Another Way…

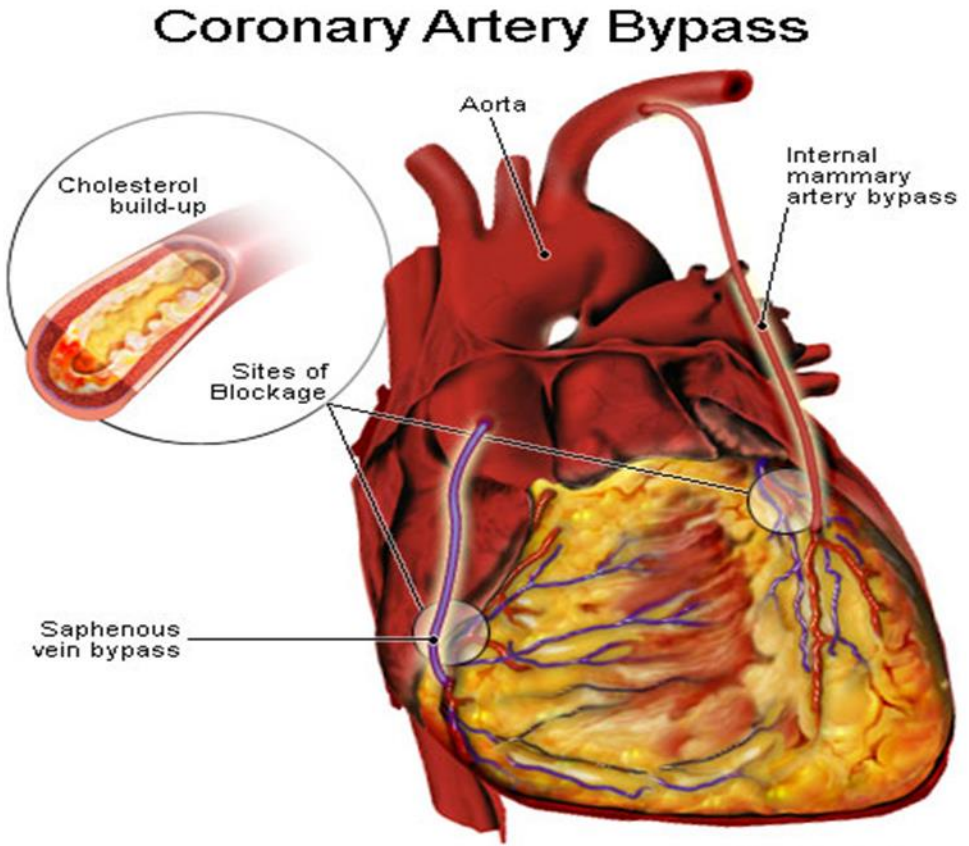
- **Outcomes for individuals with CAD are driven by the overall burden of disease**

  - **Invasive assessment: summation of all angiographically visible lesions**
  - **Noninvasive surrogate: *Coronary Artery Calcium***

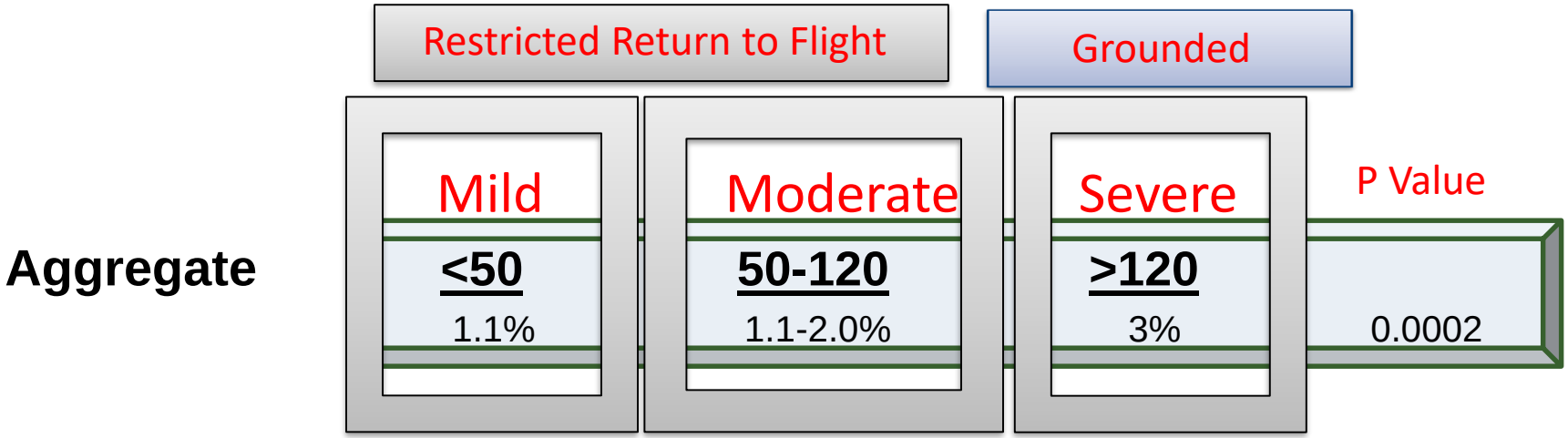
Both measures are predictive of future events in aviators with asymptomatic coronary artery disease

Revascularization





Residual CAD after Revascularization



Revascularization

- ***PCI and CABG are palliative, not curative***

- **If "successful" after the first 6-12 mo, outcomes are due to progression of CAD, including development of CAD in vein grafts**

- **Annual event rates in the best clinical subgroups have been 1%-3% per year to 4-5 yr follow-up**

Revascularization Policy

- **Minimum 6-mo DNIF observation**
- **Cardiology evaluation, including coronary angiography if otherwise waiver eligible**
- **Normal LV function, no ischemia or infarct areas at rest and at peak stress**
- **100% revascularization (all significant lesions revascularized)**
- ***No uncorrected lesion or restenosis >50%; aggregates of uncorrected lesions <120%*** **(matches CAD policy)**

Revascularization Policy

- **Must meet risk factor modification thresholds prior to initial evaluation and at each reevaluation**
- **Restricted to *low-performance* aircraft only; pilots must fly with another qualified pilot**
- ***Annual reevaluation* with full noninvasive testing. Adherence to aggressive risk factor modification.**
- **Serial coronary angiography every 5 yr routinely (NEW), earlier if indicated by symptoms or noninvasive tests**

NATO WG RECOMMENDATION

HFM – 251 recommendations

Recommendations:	**Class**
Bare metal stents and drug eluting stents are acceptable for aircrew	I
Because of the high rate of early restenosis, non-stent angioplasty (POBA) is not recommended for aircrew	III
Fully bioresobable stents/scaffolds are not recommended for aircrew	III

HFM – 251 recommendations

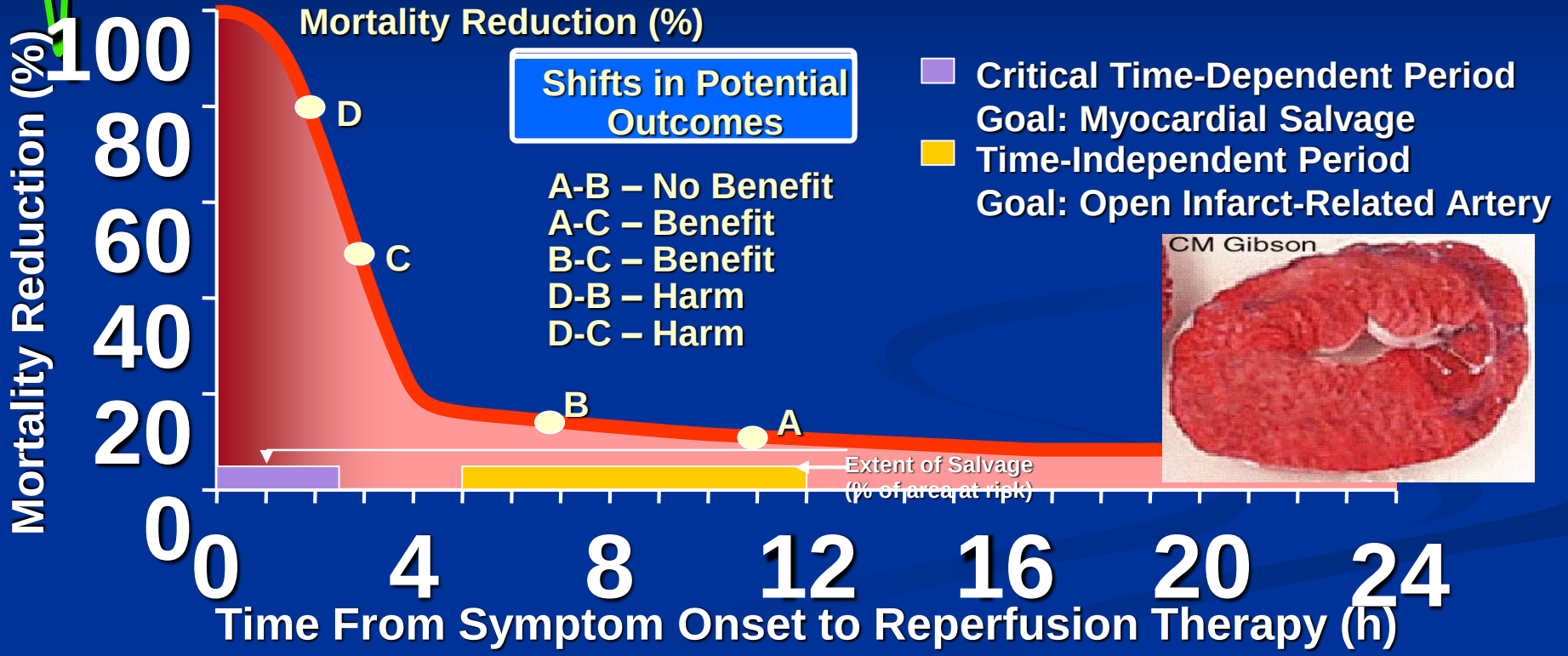
Recommendations :	Class
Published clinical guidelines rather than aeromedical considerations should be the primary consideration for determining revascularization with PCI or CABG.	I
Revascularization may be considered for occupational risk modification outside clinical indications after thorough discussion and consent with the aircrew.	IIb
For aircrew being considered for proximal LAD revascularization, proactive consideration should be given to LIMA graft over PCI given long term benefit.	IIa
Because of the potential for early complications, a waiting period of at least six months after revascalarization is required before assessing aircrew for return to flight status.	I

Myocardial Infarction

Coronary Artery Disease & Revascularization

- Asymptomatic CAD
- Revascularization
- Myocardial infarction
  - Treated conservatively
  - Treated with thrombolytics
  - Treated with acute revascularization

Hypothetical Relationship Between Early Reperfusion, Mortality Reduction, and Extent of Myocardial Salvage



Gersh BJ, et al. *JAMA*. 2005;293:979-986.

Myocardial Infarction

- **USAF "experience" in older, former aircrew with MI**
  - **Cardiac event rate about 2.5%/yr out to 5 yr, NO cardiac deaths**
- **Cardiac literature similar demographic groups**
  - **Event rates also 2.0%-3.0%/yr**
- **Coronary revascularization policy approved in 2008 with similar event rates from ACS former aircrew database and cardiac literature**
  - **Assumed event rate of 2.0%-3.0%/yr acceptable for low performance and nonpilot or dual pilot status**
  - **Anticipated actual event rate 1.0%-2.0%/yr or less**

Myocardial Infarction Policy

- **IDENTICAL to Revascularization Policy for USAF**
  - **Minimum 6-mo DNIF observation followed by…**
  - **Full ACS evaluation, including coronary angiography and be 100% revascularized**
  - **Normal LV function at rest and at peak stress (by nuclear imaging and/or stress echo)**
  - **No evidence of reversible ischemia**
  - **Must meet risk factor modification thresholds prior to initial evaluation and at each reevaluation**

NATO WG Recommendation

HFM 251 recommendations

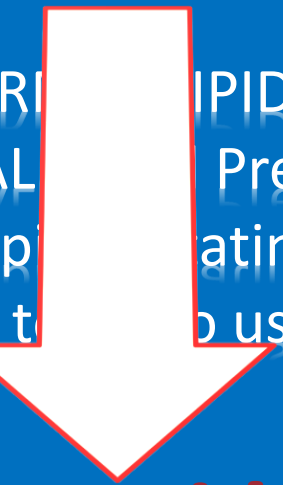
Recommendations :	Class
Cardiology specialist consultation is strongly recommended for all aircrew with suspected myocardial infarction before a return to flight/control duties	I
CMR is recommended in all aircrew where there is diagnostic uncertainty of myocardial infarction.	I
Aircrew with a history of myocardial infarction with active CHF, tobacco use, or uncontrolled diabetes should not be returned to flight duties	III
Aircrew with a history of MI may be considered for a return to restricted flight duties (with another pilot in non-high performance airframes) if the scar burden is small (still normal overall systolic function), no evidence of ischemia or arrhythmia, acceptable CAD burden, and normal functional status	IIb

Aggressive Risk Factor Modification

Secondary Prevention	Evidence*	Risk Reduction	References**
	Medical Therapy		
Statin Therapy	Strong	10-30%	1,3
Aspirin Therapy	Medium	20-25%	1,3
Blood Pressure Control	*Strong*	20%	1,3
	Lifestyle Therapy		
Tobacco Cessation	Strong	30-40%	3
Diet Control / weight loss	Medium	20-30%	3
Physical Activity	Medium	20-30%	1
Moderate Alcohol	Weak	17-30%	1
PSK9 Inhibitor	Medium	15%	4
Combined Total Risk Reduction		**19 - 47%**	**1,2,3**

Coronary Artery Disease Summary

AGGRESSIVE RISK FACTOR REDUCTION!!!



NORI IPIDS
NORMAL Pressure
Asp atin
NO t o use

Decreases risk 50%

Questions?

Eddie D. Davenport, M.D., F.A.C.C.
Lt Col, USAF, MC, FS
Chief Cardiologist Aeromedical Consultation Service
USAF/SG Chief Consultant for Aerospace Cardiology
eddie.davenport@us.af.mil / mydrdavenport@gmail.com

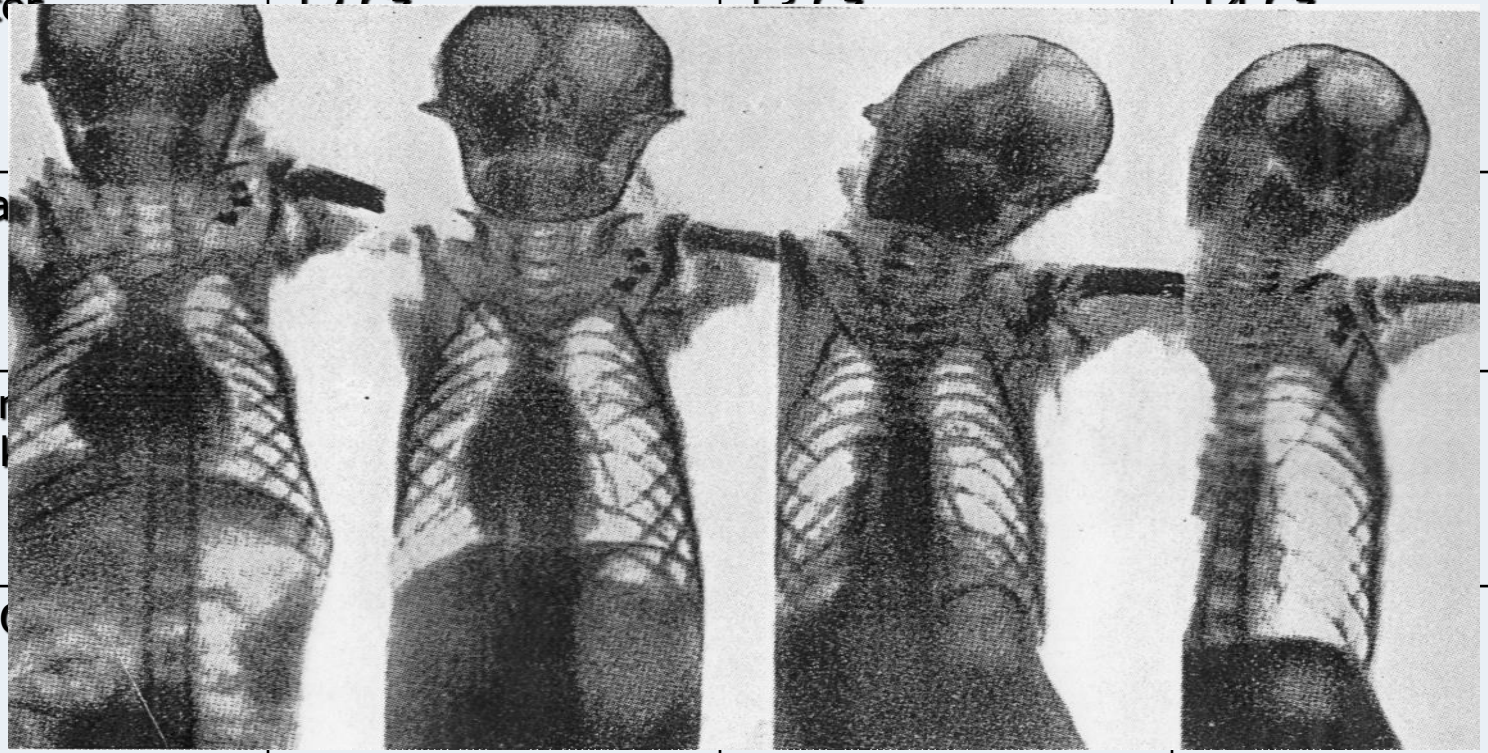
U.S. Air Force Central ECG Library

- **Serves as a repository of all cardiovascular studies on rated aviators in the USAF, USAFR, and ANG since 1957**
  - AFI mandate, all rater aviators (pilots, navigators, flight docs, air battle managers, load masters) for both surveillance and other cardiac studies accomplished for any reason.

- **Aeromedical disposition and waiver policy**
  - 60 yr of aviator data for a specific population
  - Outcomes data and policy change almost monthly
  - Work groups for normal, variant normal, and abnl
  - **FCI** = initial pilot training, **FCII** = trained asset, **FCIII** = non-pilot duties

Effect of 2, 3, and 4 +Gz on Selected Physiologic Parameters

Parameter	+2 Gz	+3 Gz	+4 Gz
Heart Ra			
Stroke In (ml/strok			
Cardiac			



CT Coronary angiography