

# **Age Limitations Commercial Air Transport Pilots**

## **Screening of Cardiovascular Risks in Asymptomatic Pilots**

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## Disclosure Information

*Ries Simons, M.D.*

I have no financial relationships to disclose.

**Panic at 34,000ft after pilot has a heart attack and dies in cockpit midway through flight**

**Captain Lands Plane After Co-Pilot Suffers Fatal Heart Attack**

**United flight lands safely after pilot has heart attack**

Ben Mutzabaugh | USA TODAY  
Published 4:20 PM EDT Sep 27, 2013

## **IndiGo Pilot Suffers Mid-Air Cardiac Arrest, Safely Lands Plane Full of Passengers!**

Bracing himself against the pain, Captain Acosta managed to touch-down at the Kolkata airport before being rushed to a nearby hospital for emergency surgery!

# Pilot's deadly in-flight heart attack threatens to renew age debate

## Age-dependent causes of sudden incapacitation:

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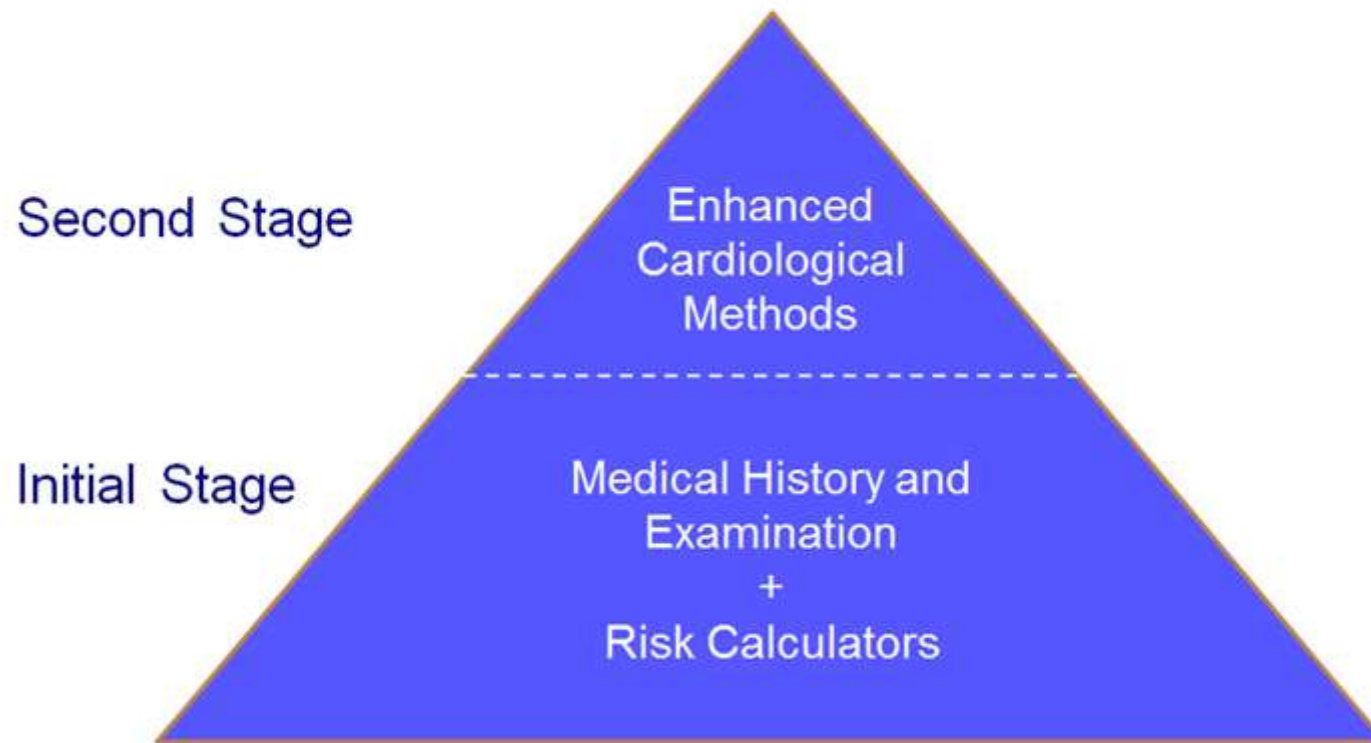
- Sudden Death
- Acute Coronary Syndrome
- Cardiac Arrhythmias
- Pulmonary Embolism
- TIA and Stroke
- Syncope
- Late-onset Seizure(s)
- Acute Psychosis



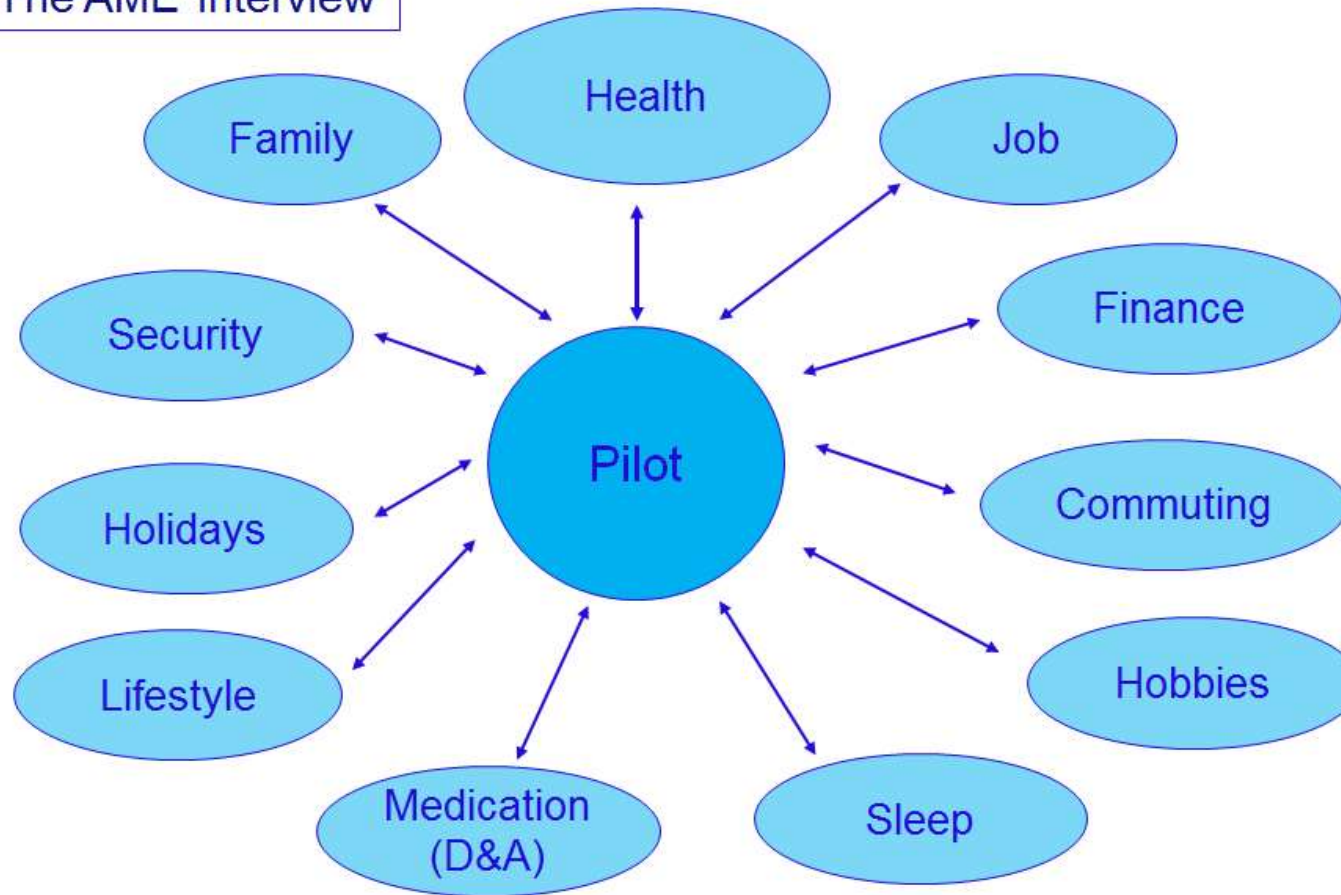
## Screening of Cardiovascular Risks in Asymptomatic Pilots

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A stratified risk assessment is recommended for pilot screening to prevent in-flight cardiovascular incapacitations



## The AME Interview



[adapted from Hudson & Herbert, 2017]



Routine 12-lead ECG is not a good discriminator of significant CAD in isolation.

In the initial cardiovascular screening a routine 12-lead resting ECG is recommended to identify abnormal conduction or other arrhythmogenic patterns that could increase the risk of cardiovascular incapacitation in aircrew



## Exercise Stress Testing

Low sensitivity: 61% [e.g. Gibbons et al. 2000]



- 39 of 100 individuals with angiographically demonstrated obstructive coronary disease will have a normal (negative) Ex-ECG.

Positive predictive value for future coronary events is very low: 24%  
[e.g. Nicol, 2018]

Ex-ECG not recommended for initial screening of asymptomatic  
aircrew



# GENETIC TESTING



You are: WHITE

You will live: PROBABLY 60-70 YEARS

Use of genetic markers for prediction of CVD is not recommended  
[European Guidelines on cardiovascular disease prevention in clinical practice -  
Euro Heart J 2016; 37:2315-81].

No agreement:

- which genetic markers should be included
- how genetic risk scores should be calculated
- + improvement in CV risk prediction: unclear

A positive family history of premature CVD is considered to represent a good surrogate for an increased genetic risk

[Ridker et al., 2008; Ridker et al., 2007; Murabito et al., 2005].

# Biomarkers

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- High sensitivity C Reactive Protein ( hs-CRP) is a sensitive but non-specific biomarker of inflammation. A level of  $\geq 2.0$  mg/L is considered a marker of cardiovascular risk.
- Increased serum apolipoprotein B (Apo B) concentration is considered an important coronary heart disease risk factor.

## American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. [J Am Coll Cardiol. Nov 3, 2018]

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- Measurement of ApoB is of uncertain value and is not yet recommended to include it in the risk assessment of a first CVD event.
- hs-CRP and Apo B can be used as 'risk-enhancing factors' that are not considered in the risk calculator: an intermediate risk found with a risk calculator can be 'enhanced' to a higher risk level when hs-CRP is  $\geq 2.0$  mg/L or Apo B is  $\geq 130$  mg/dL.

## Risk Estimation “Calculators” – criteria for consideration

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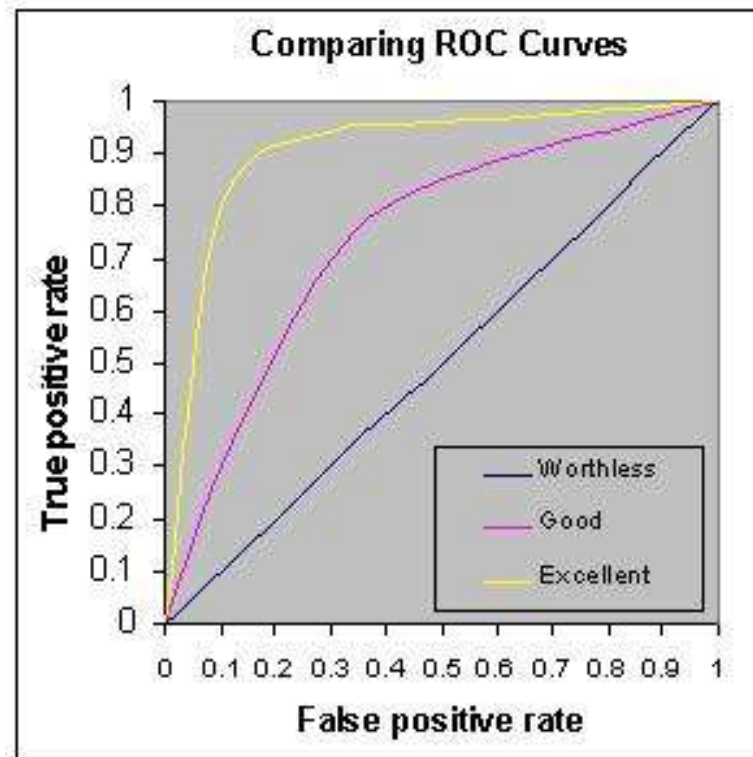
- Should be made for primary prevention of CVD relevant for European populations: derivation cohort of the risk tool should be representative for several European countries or should be externally validated using EU cohorts;
- Should be derived from cohorts of >1,000 participants of one gender without CVD, enable risk assessment for a period  $\geq 5$  yrs, have an age-range >25 years and published after 2000;
- Minimum requirement: AUROC value of 0.75 [Grover & Lowensteyn, 2011]

AUROC: Area Under the Curve of the Receiver Operating Characteristic → discriminatory power

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AUROC : ability of the test to correctly classify those with and without the disease.

0.90-1 = excellent (A)  
0.80-.90 = good (B)  
0.70-.80 = fair (C)  
0.60-.70 = poor (D)  
0.50-.60 = fail (F)



All available risk estimation tools are primarily developed for prevention of CVD and there is no risk estimation tool developed to predict the specific CVD-incapacitation risk of pilots.





## Risk Estimation Tools

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Based on conventional risk factors:

age, gender, smoking, blood pressure, and cholesterol.

Some tools add diabetes mellitus, family history of CVD, and differentiate lipids: LDL-C, HDL-C, Triglycerides.

## Most Popular Risk Calculators have AUROC 0.75 - 0.85

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- ✓ Framingham Risk Score
- ✓ SCORE
- ✓ QRISK 1, 2, 3
- ✓ Pooled Cohort Equations
- ✓ Reynolds Risk Score
- ✓ PROCAM/AGLA

## Framingham Risk Score

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➤ Advantages:

Externally validated in European population cohorts

➤ Limitations:

Based on US cohorts 1968-1987: overestimation of risk.

Risk factors do not include LDL-C

## SCORE

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### ➤ Advantages:

Based on 12 EU cohort studies; Recalibrated in many EU countries

### ➤ Limitations:

Estimates only fatal CVD risk. Based on data of 1972-1991: risk overestimation. Risk factors do not include LDL-C.

## QRISK 1, 2, 3

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### ➤ Advantages:

Good discrimination for primary care patients.  
Accurate estimation for different ethnic groups.  
Large database  
Includes many risk factors

### ➤ Limitations:

Primarily developed to predict CVD risk in England and Wales.  
Performance in other countries unclear

## Pooled Cohort Equations

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### ➤ Advantages:

Based on large, but older US database.

Applicable for African-Americans

### ➤ Limitations:

Not externally validated or recalibrated in EU cohorts.

Alleged overestimation of risk. Risk factors do not include LDL-C.

## Reynolds Risk Score

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### ➤ Advantages:

Risk factors include high sensitivity-CRP

### ➤ Limitations:

Not externally validated or recalibrated in EU cohorts.  
Based on US cohort of physicians / health care workers (volunteers). Risk factors do not include LDL-C.



## PROCAM/AGLA

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### ➤ Advantages:

Based on EU cohorts and externally validated in many EU countries. Adaptable to specific populations (risk multipliers).  
Point score for stroke risk.

### ➤ Limitations:

Older versions still on internet. Only 2007 version and AGLA have broad age range + apply to females

## PROCAM/AGLA

Derivation Cohort	Germany: Healthy employees. Baseline: 1978–1995 18 460 male, 8515 female followed for 11.7 yrs average
Calculates:	1) 10-year risk fatal + non-fatal coronary events; (Low <10%, Intermed. 10-20%, High >20%)  2) Cerebral ischaemic events
Age Range	20–75 yrs
Variables	Sex, age, LDL-C, HDL-C, SBP, smoking, DM, family CVD
EU Validated?	Yes in many EU cohorts; (MONICA data for country-specific risk multipliers)

## PROCAM Healthcheck

<http://cmd-taskforce.org/risk-assessment/>

Units:

Age:  65 Years

Gender: ☒ Male ☐ Female

Diabetes mellitus / BZ  $\geq 6.66$  mmol/l: ☒ No ☐ Yes ?

Current smoker: ☒ No ☐ Yes

Family history of heart attack: ☒ No ☐ Yes ?

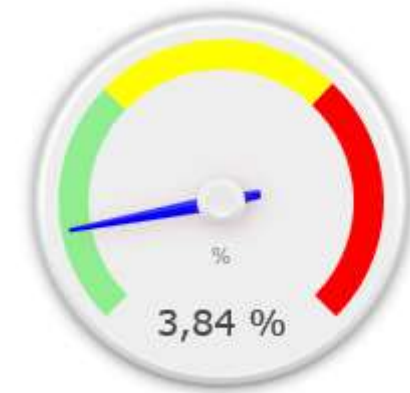
Systolic blood pressure:  130 mmHg

LDL Cholesterol:  2.5 mmol/l

HDL Cholesterol:  1.6 mmol/l

Triglycerides:  1.6 mmol/l

Risk: 3.84% \*\*



The 2018 AHA/ACC Guideline on the Management of Blood Cholesterol: non-fasting lipid profiles test results are sufficient for assessing prognosis.

Non-fasting directly measured LDL-C is adequate

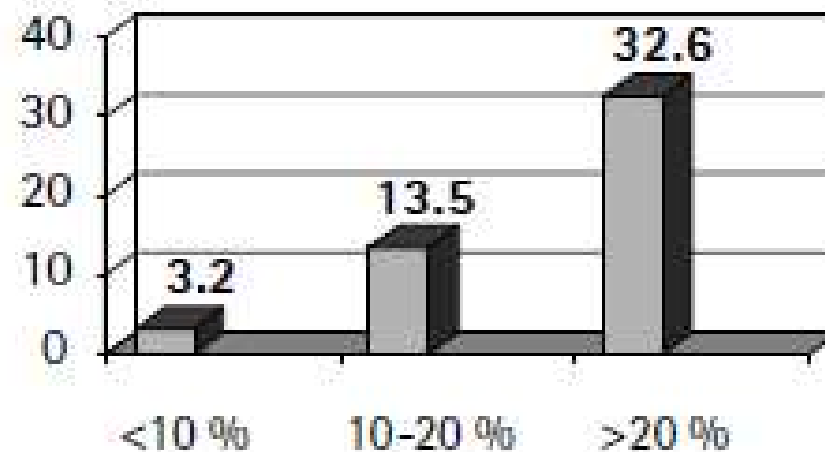


Non-fasting calculated LDL-C is adequate unless triglycerides are greater than 400 mg/dL (4.52 mmol/L), which requires a repeat test while fasting.

[Alenghat et al. JAMA. 2019;321(8):800-801]

## Observed risk of acute coronary events in 5,389 men aged 35-65 years according to categories of absolute risk

Mean risk of acute coronary event  
(% within 10 years)



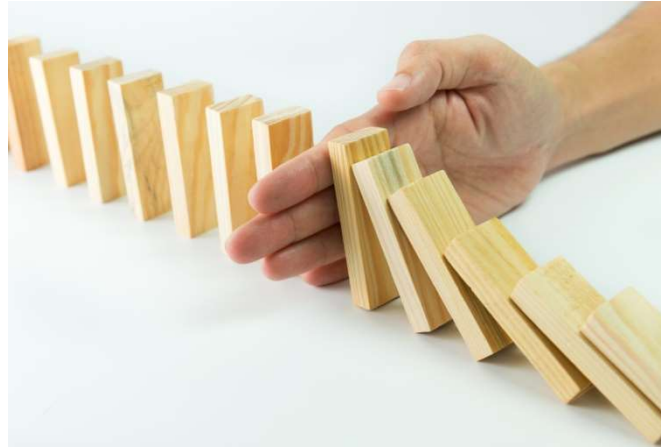
Estimated risk in 10 years

Prevalence of this category  
in the PROCAM cohort

Estimated risk in 10 years	Prevalence of this category in the PROCAM cohort
<10 %	77.4 %
10-20 %	15.0 %
>20 %	7.5 %

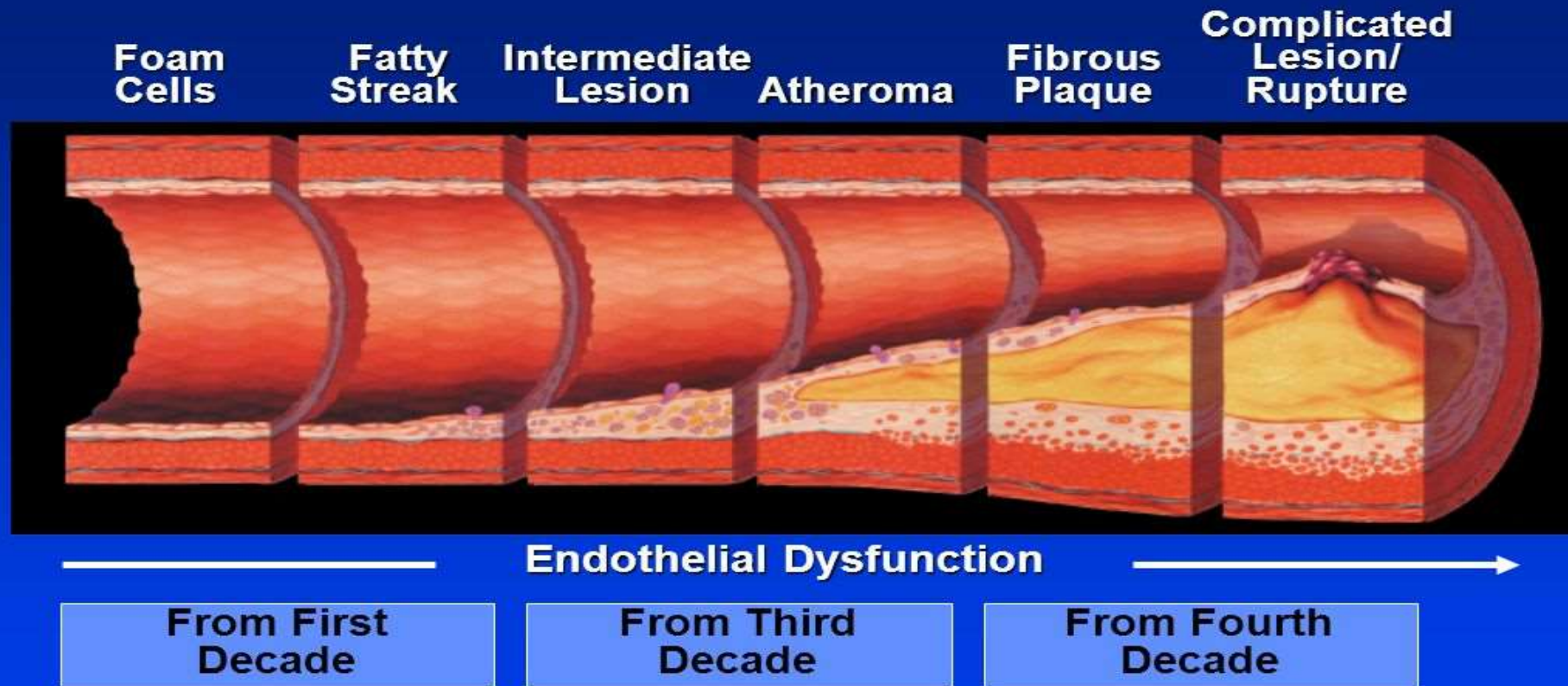
[Assmann et al., 2007]

# Prevention



1. Reduces Individual CVD risk
2. Reduces sudden incapacitation risk by reducing number of cases at risk

# Atherosclerosis Timeline



Adapted from Pepine CJ. *Am J Cardiol.* 1998;82(suppl 104).



# Russian pilot dies of heart attack mid-flight



Moscow, Jan 21, 2012, (IANS/RIA Novosti), JAN 21 2012, 11:29AM IST | UPDATED: MAY 04 2018, 10:21AM IST

A pilot of a UTair Boeing 757 flying from Bangkok to Novosibirsk in Russia's Siberia region died as the plane was flying over China, officials said.

Sergei Golev, 44, sustained a heart attack in the cockpit and died despite all attempts at resuscitation, a local prosecutor's office spokeswoman said.

The number of pilots at risk for CVD increases with age

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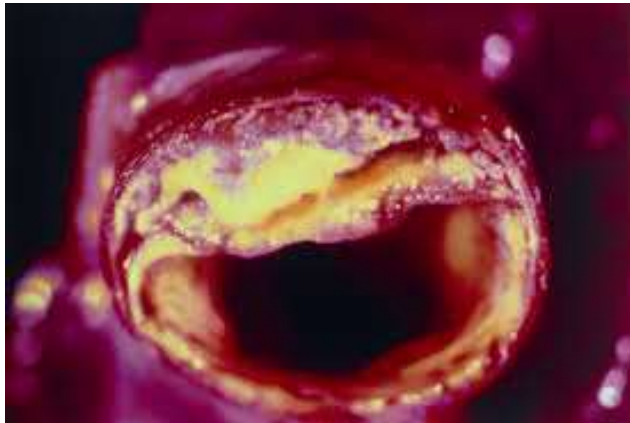
Mortality all cardiovascular diseases and myocardial infarction:

3-fold increase in those over 40 years [AHA, 2018]

5-fold Increase of new stroke cases in 45-54 age group  
compared with the under 45 age groups

[Finegold et al., 2013; Buddeke et al., 2017].

Prevalence of MI: 0.5% men - 0.18% women 35-44 yrs  
20.5% men - 17.1% women >60 yrs



Fournier et al. Myocardial infarction in men aged 40 years or less: a prospective clinical-angiographic study. Clin Cardiol. 1996;19(8):631

Doughty et al. Acute myocardial infarction in the young--The University of Michigan experience. Am Heart J. 2002;143(1):56

- 1) The number of pilots at risk for CVD increases with age
- 2) Medical examination will only detect a proportion (66%?)  
of serious conditions [adapted from Evans, 2011]

Number of missed high risk cases is considered to increase  
when age increases

# Prevention

Reduces sudden cardiovascular incapacitation risk  
by reducing the number of cases at risk

## Conclusions

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- Stratified cardiovascular risk assessment to reduce the in-flight medical incapacitation risk in older CAT pilots.
- A Comprehensive Aeromedical Examination is the mainstay of medical risk assessment

## Conclusions

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- Periodically screen all aircrew  $\geq 40$  years on cardiovascular risk using resting ECG and risk estimators ('calculators') representative and appropriate for the population to screen and include family history and provide non-fatal and fatal endpoints.



## Conclusions

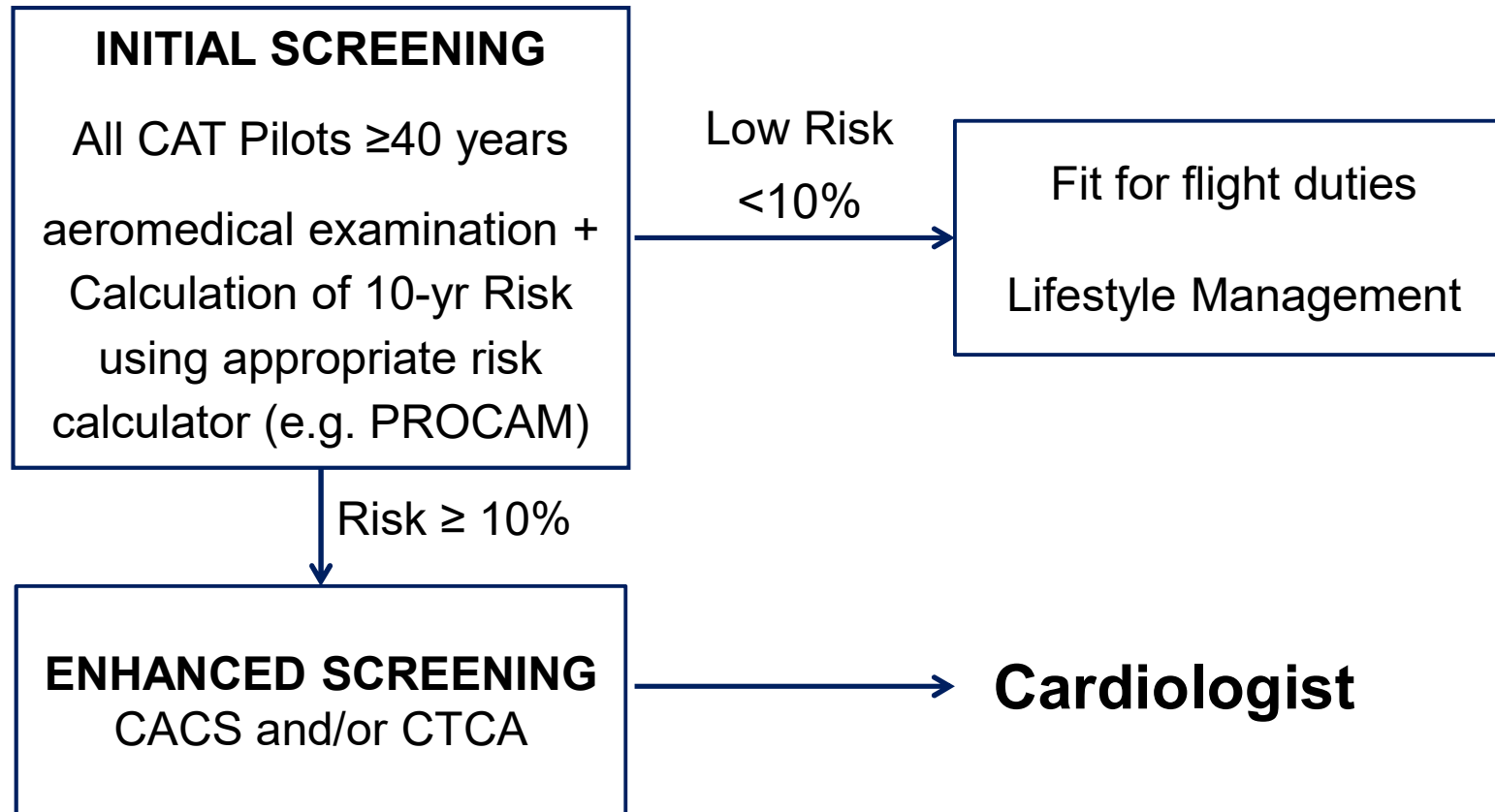
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- PROCAM/AGLA: risk level  $\geq 10\%$  10-year risk of 'hard' CVD events: further cardiological risk assessment using enhanced methods, such as CACS and/or CTCA.
- Pilots with borderline risk 5 - 10%: thorough lifestyle counselling with emphasis on preventive diet and exercise measures.

## Conclusions - Recommendation

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- The systematic cardiovascular risk assessment should be evaluated on efficacy and cost-effectiveness:  
National Authorities should collect data of:
  - all individual cardiovascular risk scores
  - consequences of the score (actions taken)
  - outcome of enhanced screening



## Cardiologist

### ENHANCED SCREENING CACS and/or CTCA

#### LOW RISK:

CACS <100 or CTCA-single  
or aggregate stenoses <50%  
good functional capacity

#### HIGH RISK:

CACS >100 or CTCA-single  
stenosis >50% or CTCA-  
aggregate stenoses >120% or Left  
Main (LM) >30% stenosis

Fit for flight duties  
Aggressive risk  
factor modification  
for all those with  
CACS>0

Cardiological  
+ aeromedical  
advice:  
Fit or Unfit +  
preventive  
treatment

#### SECOND LINE INVESTIGATIONS:

Anatomic Imaging: CTCA or ICA;  
Functional Imaging: SPECT, PET,  
CMR, Stress -Echocardiography