



Screening and Imaging for Coronary Artery Disease in Aircrew

NATO Aviation Cardiology Working Group (RTG HFM-251)

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Chair, NATO Aviation Cardiology Working Group



65th ICASM – Rome 2017
Ed Nicol

I have no financial relationships to disclose

I will not discuss off-label use and or investigational use in my presentation



Coronary Artery Disease and Aircrew



Continental Airlines Pilot Dies on Flight From Brussels to Newark

Thursday, June 16, 2009
FOX NEWS

The captain of a Continental Airlines flight en route from Brussels to Newark died during the trip, but the flight landed safely with two co-pilots at the controls.

A doctor who examined the pilot said he likely died of a heart attack.

Dr. Julien Struyven, a cardiologist, said he responded Thursday to an announcement made on board Continental Flight 61 asking for doctors.

He examined the captain, who was already dead, and concluded that heart failure likely killed him. Struyven said there was "no chance at all" of saving the pilot, though he did use a defibrillator to try to resuscitate him.

Two co-pilots took over flying the Boeing 777, said FAA spokesman Lea Dorr.

The plane with 247 passengers aboard landed on time just before noon at Newark Liberty International Airport. It left Brussels at 9:45 a.m.

DHC-1 Chipmunk 22 (Lycoming), G-BCSB

AAIB Bulletin No: 92000	Ref: EW/C2000/0301	Category: 1,3
Aircraft Type and Registration:	DHC-1 Chipmunk 22 (Lycoming), G-BCSB	
No & Type of Engines:	1 Lycoming O-360-AAA piston engine	
Year of Manufacture:	1952	
Date & Time (UTC):	4 March 2000 at 1221 hrs	
Location:	RAF Conings, Stortford	
Type of Flight:	Private	
Persons on Board:	Crew - 3 - Passengers - None	
Injuries:	Crew - Fatal - Passengers - N/A	
Nature of Damage:	Aircraft severely damaged	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	52 years	

The post mortem examination revealed evidence of a myocardial infarction (heart attack). The pathological evidence suggests that the sequence of events was initiated by this myocardial infarction which probably occurred in the early morning of the day of the accident. Although this was not fatal at the time it is believed that the infarction extended while the pilot was initiating his second take off and that he became incapacitated. This led to the aircraft deviating to the left of the runway and subsequently crashing. The pilot had utilised the full shoulder harness fitted to the aircraft and suffered only minor injuries as a result of the impact.

BBC NEWS CHANNEL

Live Updated: Monday, 25 February 2008, 13:14 GMT

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Co-pilot dies during plane flight

A flight from Manchester to Cyprus was forced to divert to Turkey after the co-pilot died during the journey.

First Officer Michael Warren, 43, was taken ill during a GB Airways flight to Paphos on Sunday afternoon.

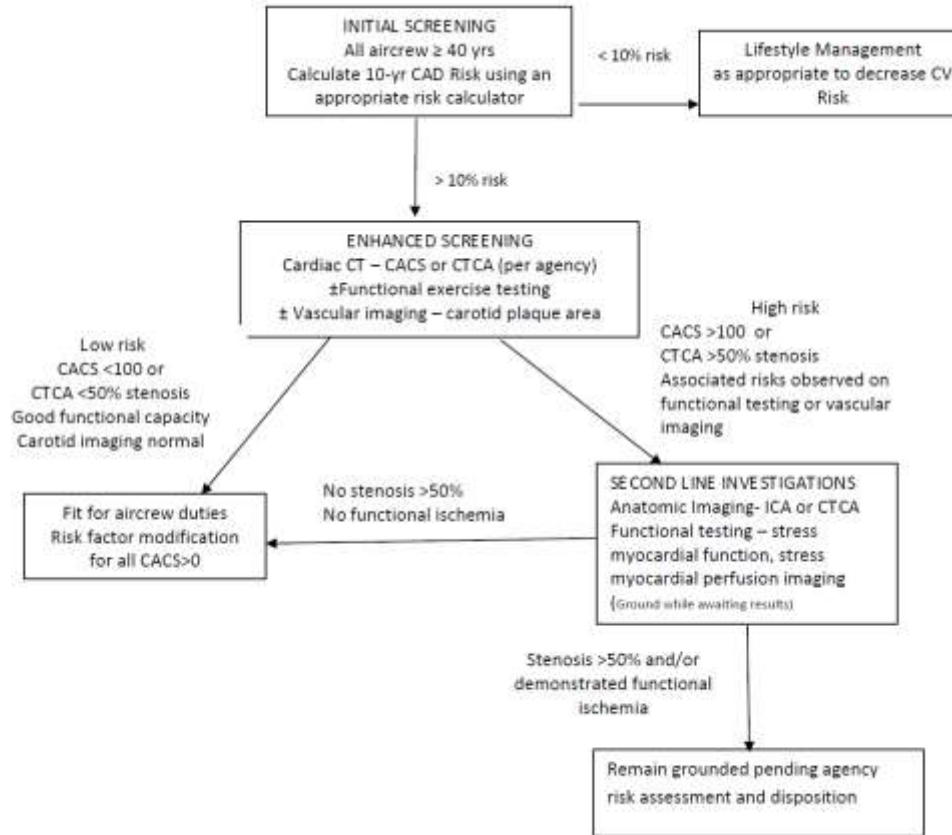
The Airbus A320, with 156 passengers on board, was re-routed to Istanbul where travellers spent the night.

A spokeswoman for GB Airways, which is a franchise partner of British Airways, said that at no time were the passengers and crew in any danger.

Mr Warren, a father-of-two from Ormskirk, Lancashire, was given first aid by the aeroplane's purser, but was pronounced dead by the Turkish authorities on arrival in Istanbul.

The spokeswoman said: "The flight, with 156 passengers and six crew members, left Manchester on time at 1420 on Sunday, 24th February."

NATO HFM-251 proposed guidelines





Detecting Plaque before the accident



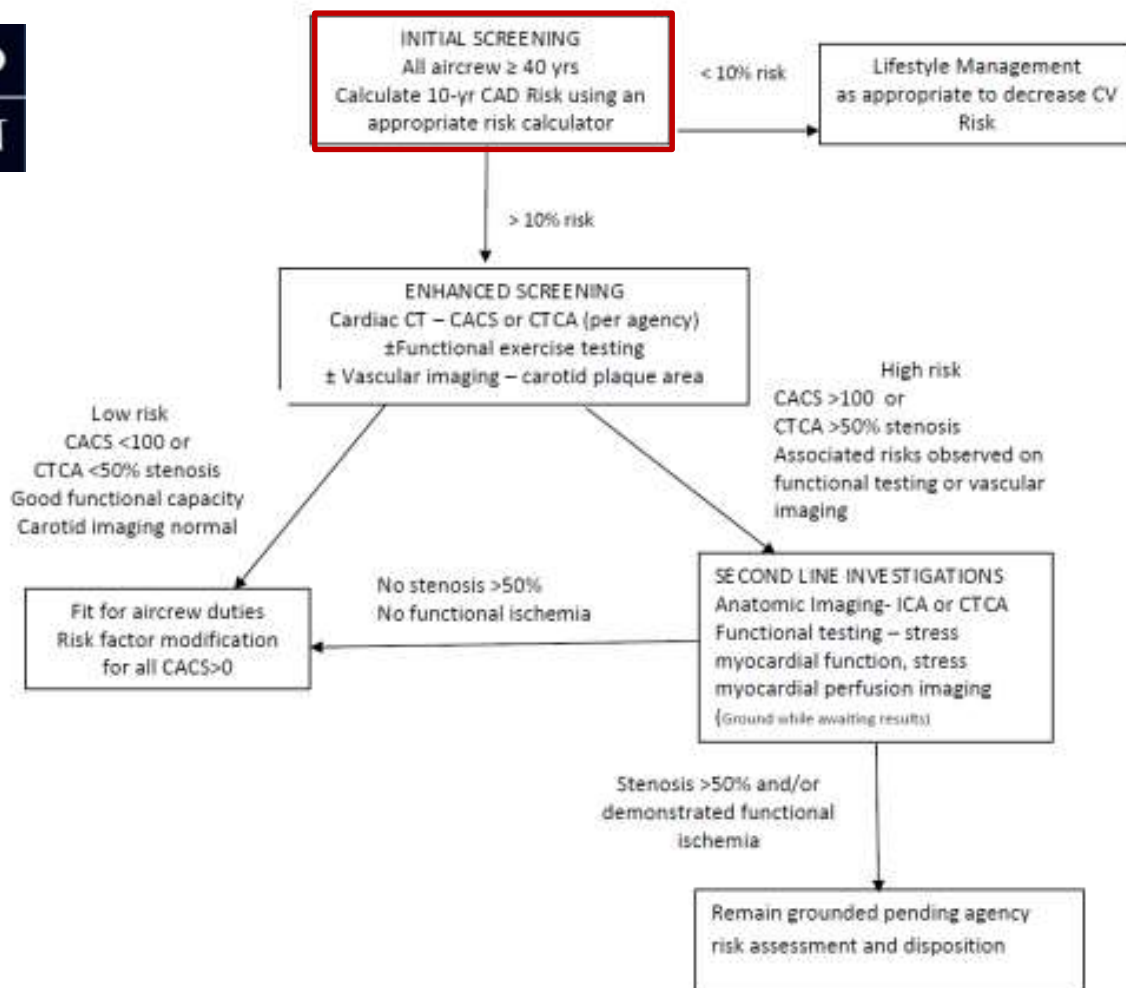
- Screening for CAD
 - First line screening
 - Enhanced screening
 - Second line investigations



Military Guidelines



- US – early use of CACS and then MPS or ICA
- UK – ECG then ETT, then usually CTCA
- Germany – ETT as a baseline, early use of CTCA
- NDL – ETT as a baseline, considering CTCA routinely
- Civil approaches also variable and counter-intuitive
- **Evidence in aircrew is lacking – what is the correct approach?**

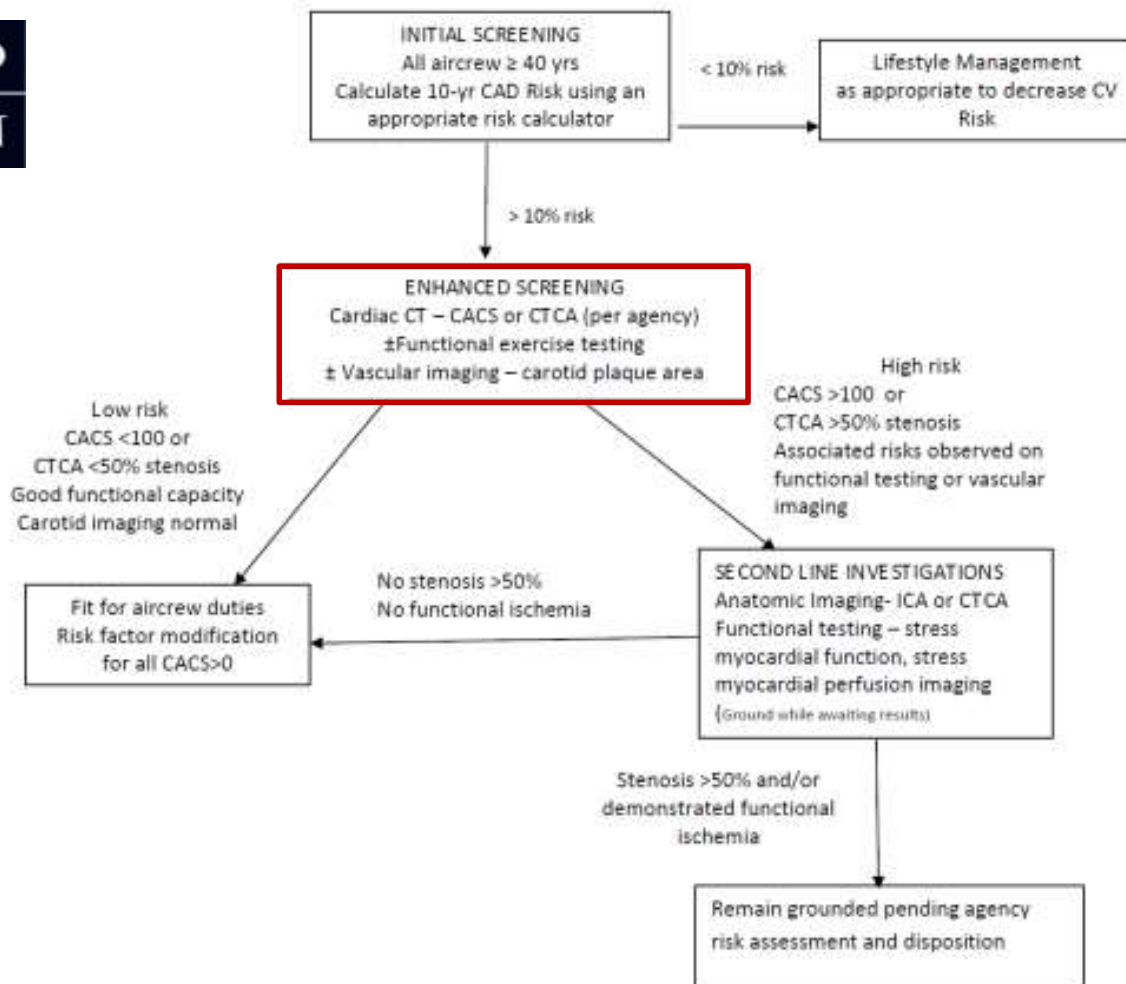




Risk Calculators



- Usually used in conjunction with 12-lead ECG
- Many available – Framingham, PROCAM, AGLA, Qrisk, Reynolds
- Limitations include age cut-offs, geographical population specific
- 10 year event rate – based on hard events (MI/CVA/death)
- FHx and possibly hsCRP add value
- **Reynolds is probably the most appropriate risk calculator for aircrew**





Enhanced Screening



- Cardiac CT
 - CACS – indicates atheroma but poor discriminator at individual level
 - CTCA gives both true anatomic detail – requires contrast
- ExECG – poor for sig CAD assessment but good for aerobic assessment
- Vascular Imaging – ultrasound carotids/femoral arteries



Ex ECG


Test with 60% Sensitivity, 90% Specificity
Population 20,000 subjects, 5% prevalence CAD

	Significant CAD	No Significant CAD
Abnormal Test	600 (TP)	1,900 (FP)
Normal Test	400 (FN)	17,100 (TN)

$$\underline{PPV} = TP / (TP + FP) = \underline{24\%}$$
$$\underline{NPV} = TN / (TN + FN) = \underline{98\%}$$

Low to intermediate likelihood of CAD— role of ExECG?




National Institute for Health and Clinical Excellence

Issue date: March 2010

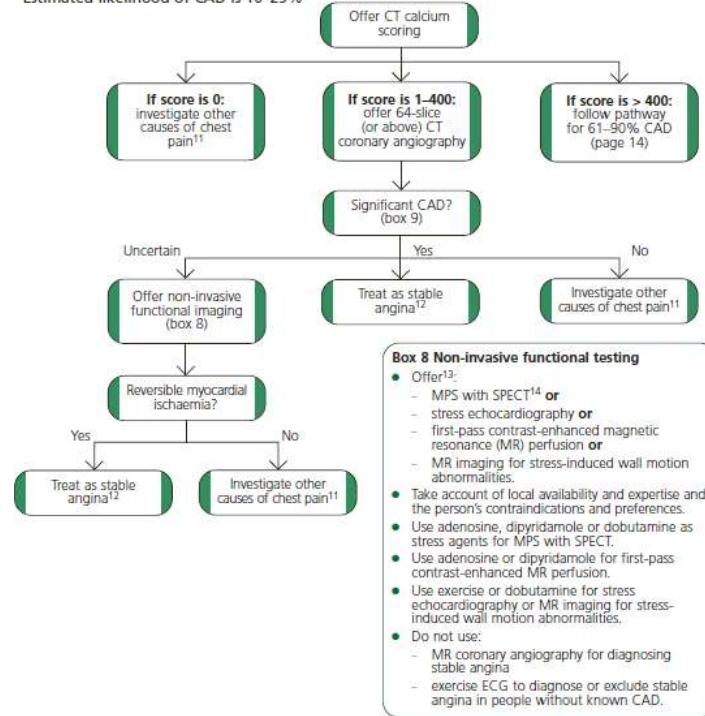
Chest pain of recent onset

Assessment and diagnosis of recent onset chest pain or discomfort of suspected cardiac origin

This guidance partially updates NICE technology appraisal guidance 73 (published November 2003)

NICE clinical guideline 95

Estimated likelihood of CAD is 10–29%





Enhanced Screening

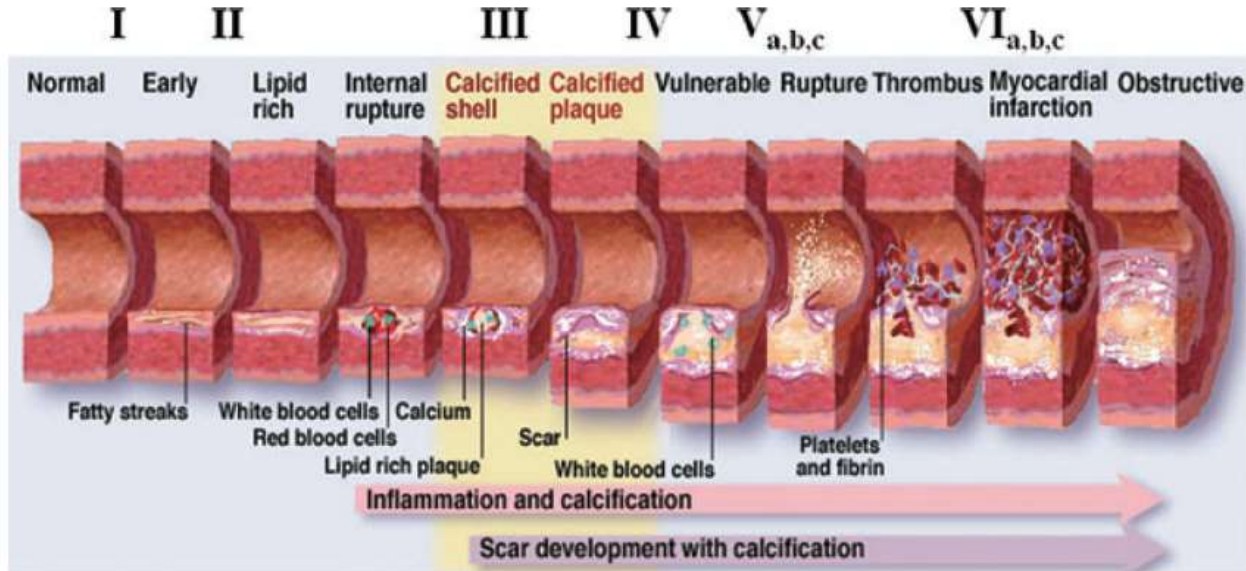


- ExECG – poor for sig CAD assessment – **should not be used to assess for significant CAD as a sole test**

Coronary Artery Calcification



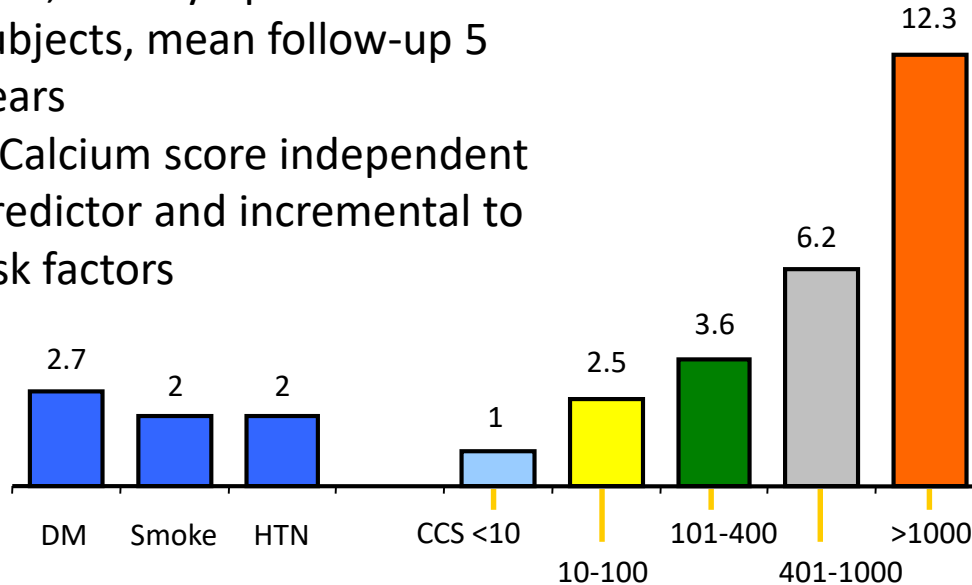
Stary Classification of Atherosclerotic Plaques



Epidemiology



- 10,377 asymptomatic subjects, mean follow-up 5 years
- Calcium score independent predictor and incremental to risk factors



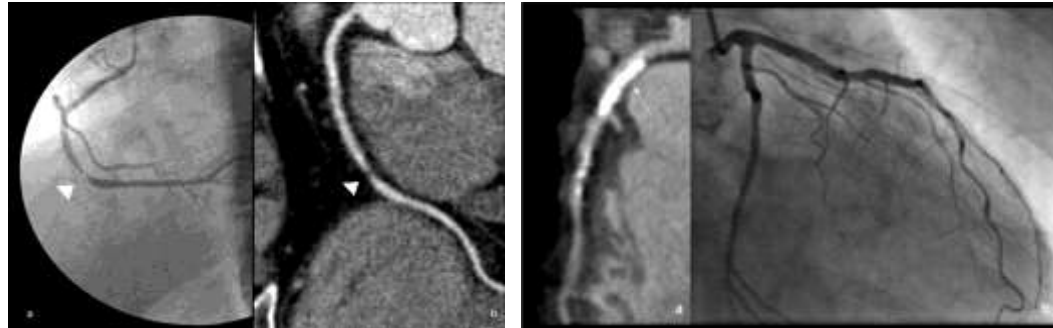
CACS



- US
 - Score <10 – unrestricted
- UK
 - <10 not reassuring
 - >100 may be OK

CAC Score:	0	1-9	10-99	100-399	400-999	>1000
n	249	51	202	263	212	112
CD/MI/ revasc	3	0	6	8	17	12
Annual event rate	0.45%	0.00%	1.11%	1.14%	3.00%	4.01%

Rozanski, et al JACC 2007





Enhanced Screening



- CACS – indicates atheroma and has strong population level data but risks being a poor discriminator at individual level – **data in aircrew?**

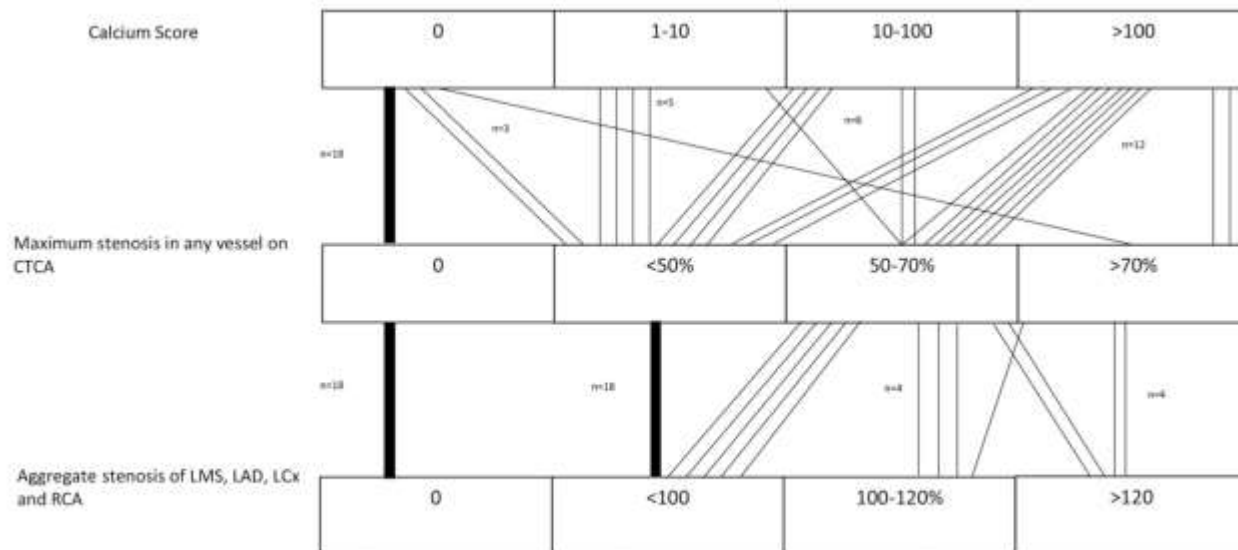


Fig. 1. Figure comparing CT calcium score, CT coronary angiography maximal stenosis, and aggregate stenosis.

CT Coronary Angiography vs. Coronary Artery Calcium Scoring for the Occupational Assessment of Military Aircrew

Iain Parsons; Chris Pavitt; Rebecca Chamley; Jo d'Arcy; Ed Nicol

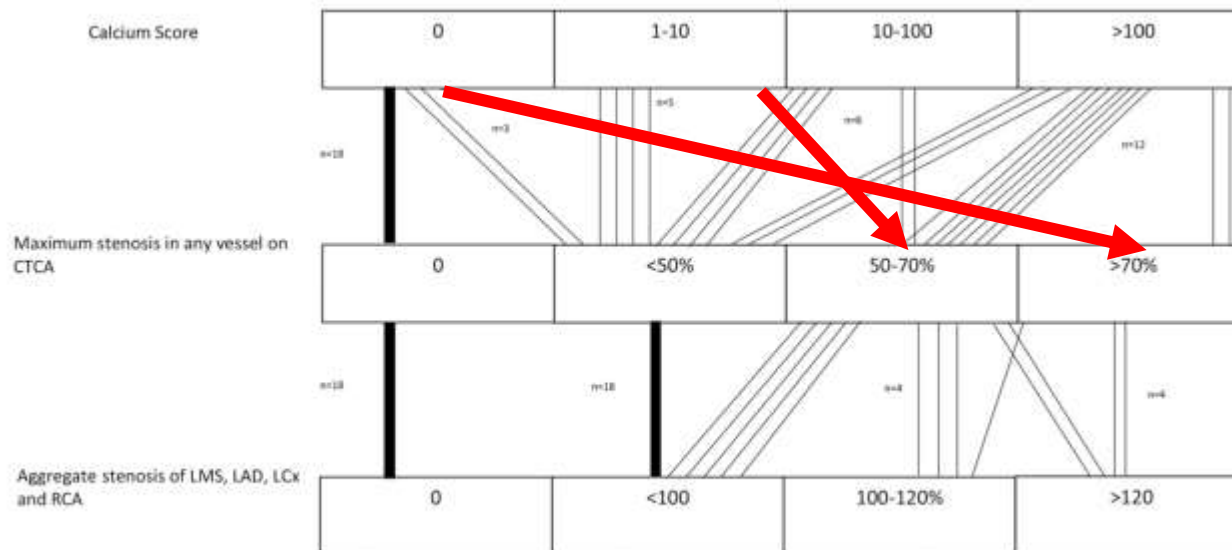


Fig. 1. Figure comparing CT calcium score, CT coronary angiography maximal stenosis, and aggregate stenosis.

Case 1



Fig. 2. CT coronary angiography of a pilot with significant LAD stenosis, but a calcium score of 0, confirmed by invasive angiography (see arrows).

CT Coronary Angiography vs. Coronary Artery Calcium Scoring for the Occupational Assessment of Military Aircrew

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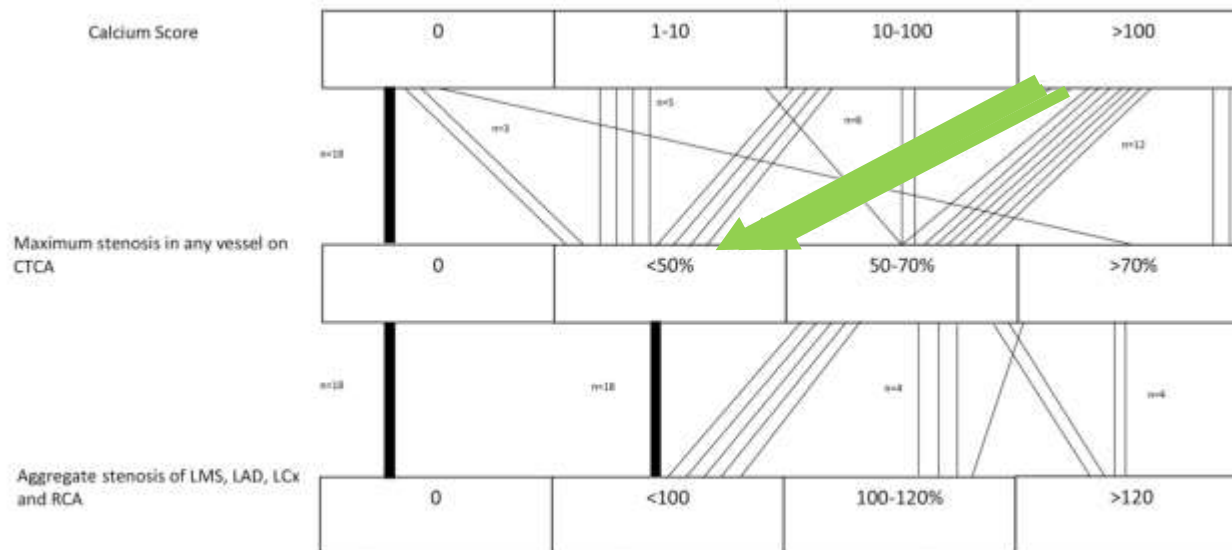


Fig. 1. Figure comparing CT calcium score, CT coronary angiography maximal stenosis, and aggregate stenosis.



Enhanced Screening



- CACS – indicates atheroma but poor discriminator at individual level –
If performed in isolation may not predict risk on individual basis



CTCA





No Ex ECG

No CACS

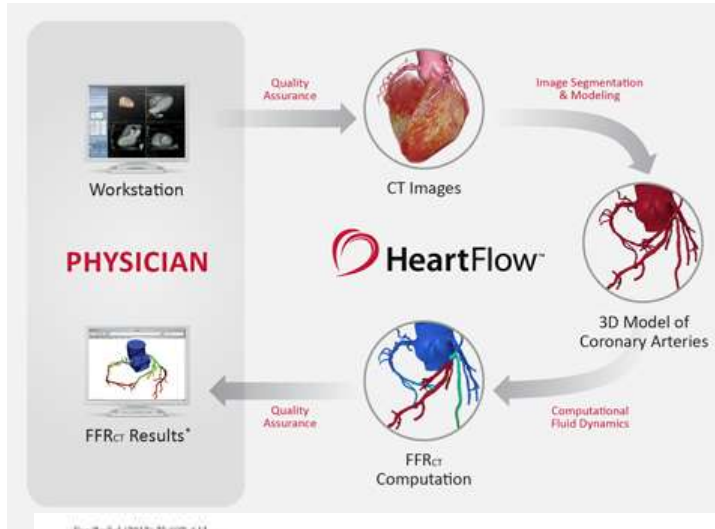
No PTP assessment

1.3.4.3 Offer 64-slice (or above) CT coronary angiography if:

- clinical assessment (see recommendation 1.3.3.1) indicates typical or atypical anginal chest pain, or
- clinical assessment indicates non-anginal chest pain but 12-lead resting ECG has been done and indicates ST-T changes or Q waves.
[new 2016]



Strengths of CTCA



Eur Radiol (2013) 23:807–813
 DOI 10.1007/s00336-012-2767-8

CARDIAC

CT coronary angiography at an ultra-low radiation dose (<0.1 mSv): feasible and viable in times of constraint on healthcare costs

Filippo Cademartiri • Erica Maffei • Teresa Arcadi •
Omar Catalano • Massimo Maffei

Received: 22 October 2012 / Revised: 13 December 2012 / Accepted: 19 December 2012 / Published online: 24 January 2013
© European Society of Radiology 2013

- Ubiquity – cardiac enabled CT
- Speed vs. ICA/MPS/CMR
- Non-invasive
- Plaque analysis
- Rapidly evolving field
- Potential for functional data
- Low dose

Weaknesses of CTCA



Letter to the Editor

The national evolution of cardiovascular CT practice: A UK NHS perspective

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^a Royal Brompton and Harefield NHS Foundation Trust, London, UK

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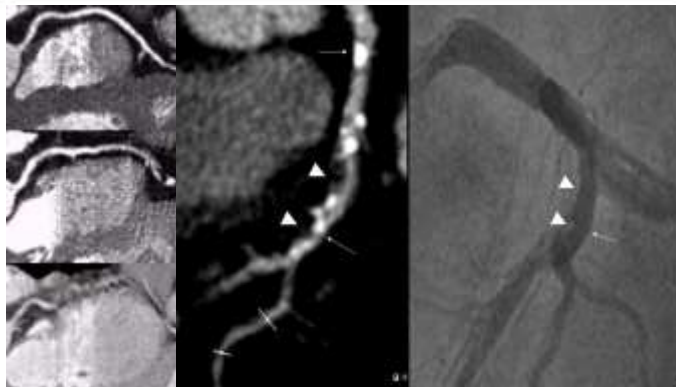
^c Plymouth Hospital NHS Trust, Plymouth, UK

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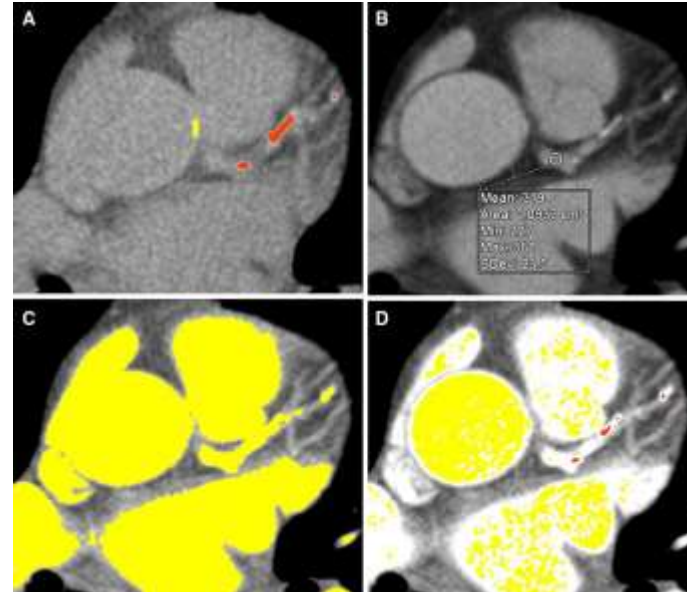
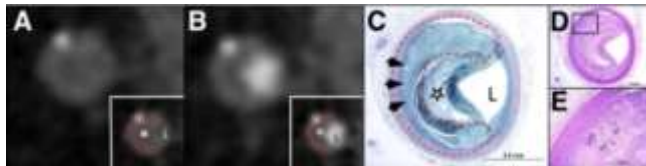
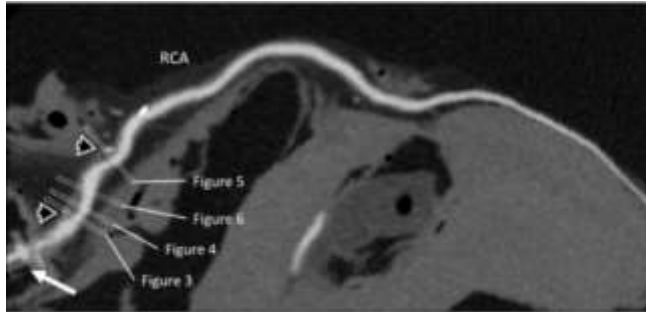
- Volume and Quality
- Heart rate and HRV limitations
- Calcium
- Radiation

- Access and cost in some nations



Deriving coronary artery calcium scores from CT coronary angiography: a proposed algorithm for evaluating stable chest pain

Christopher W. Pavitt · Katie Harron · Alistair C. Lindsay ·
Robin Ray · Sayeh Zielke · Daniel Gordon · Michael B. Rubens ·
Simon P. Padley · Edward D. Nicol

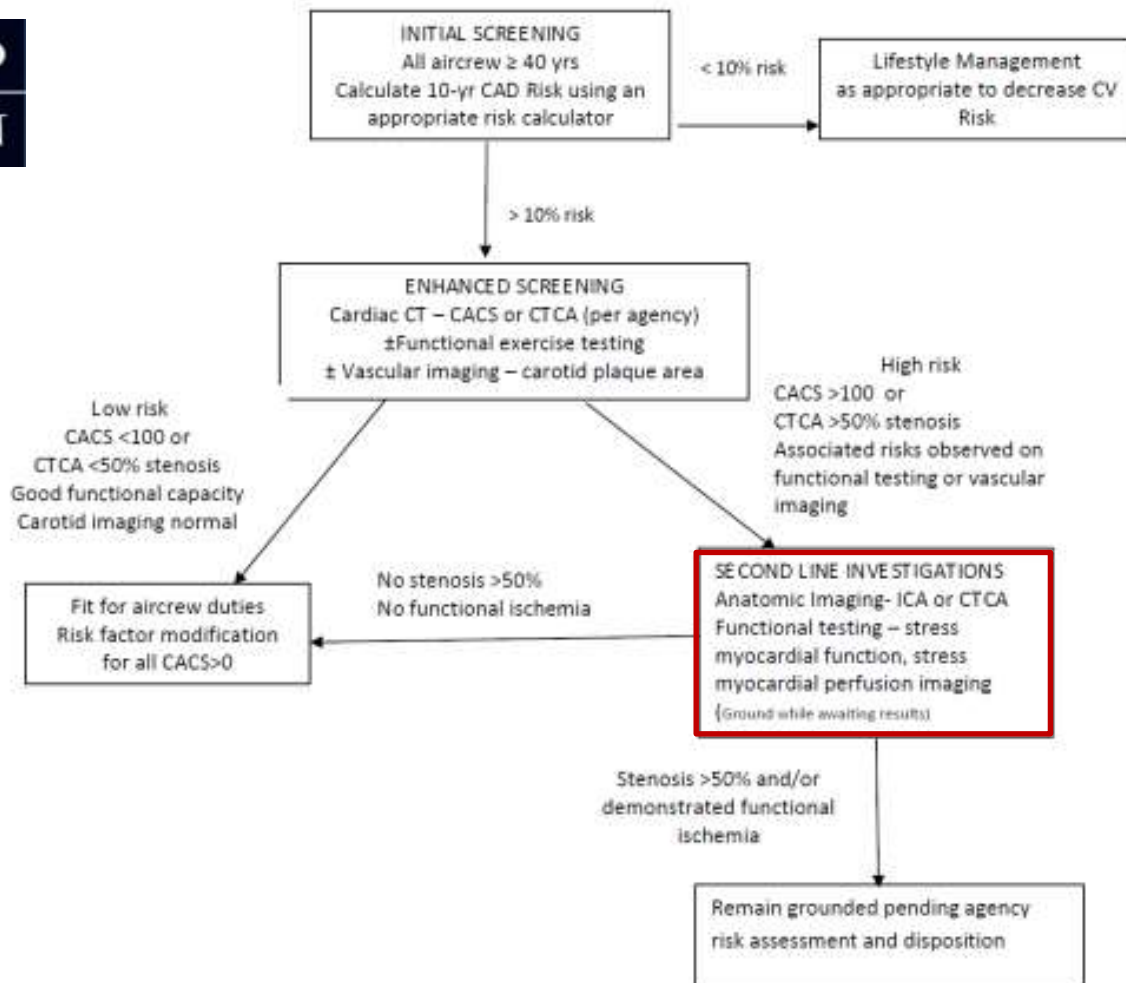




Enhanced Screening



- CTCA gives both true anatomic detail – requires contrast - **consider as alternative/addition to CACS**



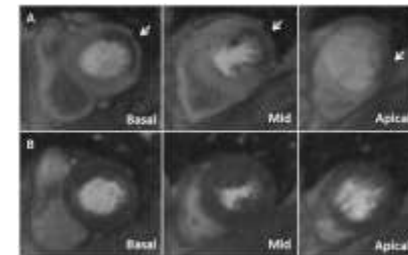
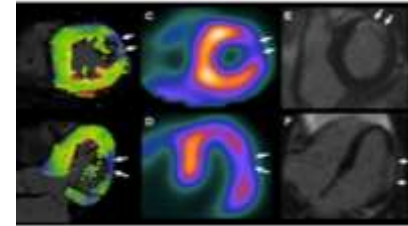
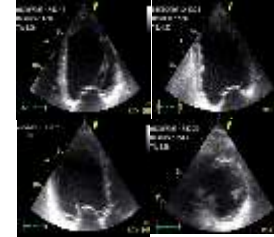
Second line investigation



- Anatomic – CTCA or invasive angiography

Before

- Functional imaging
 - Perfusion
 - Wall motion
- Ground whilst investigating
- **A normal functional scan (without anatomic investigation) will not tell you if there is aeromedically significant coronary artery disease**





NICE CG95 Guidelines



Addendum to Clinical Guideline (CG95), Chest pain of recent onset: Assessment and diagnosis

*Clinical Guideline Addendum: CG95.1
Methods, evidence and recommendations
April 2016*

National Institute for Health and Care
Excellence

Draft for consultation

- 1.3.5.1 Offer non-invasive functional imaging (see section 1.3.6) for myocardial ischaemia if 64-slice (or above) CT coronary angiography has shown CAD of uncertain functional significance or is nondiagnostic. **[2016]**



Summary



- Appropriate risk calculators should be used
- ExECG should not be used to assess for significant CAD as a sole test
- CACS alone may miss important CAD
- CTCA gives true anatomic detail non-invasively
- Anatomic imaging should be performed prior to functional imaging

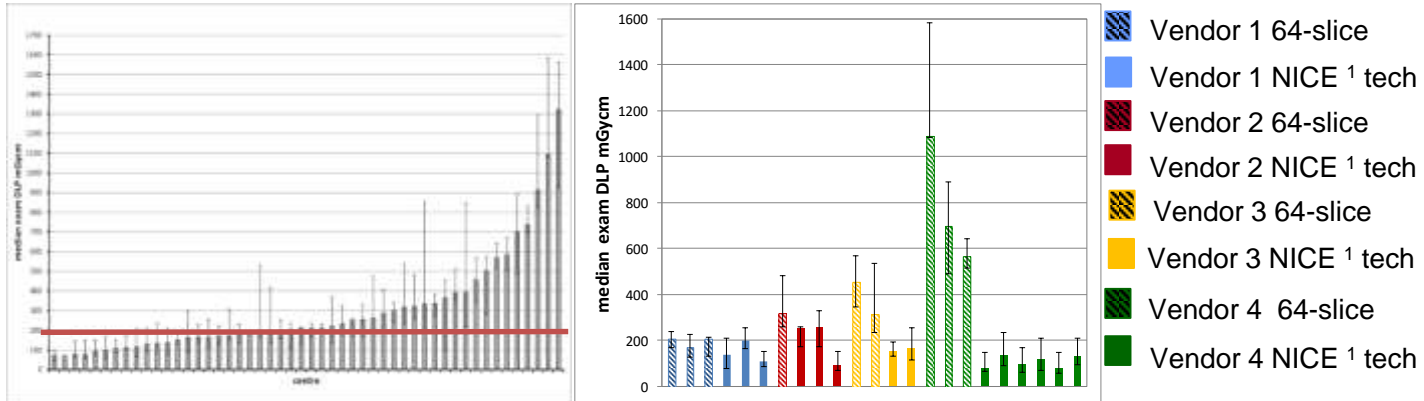


QUESTIONS?

UK National Radiation Survey



- Maintaining standards and dose



¹ National Institute for Health and Care Excellence. New generation cardiac CT scanners (Aquilion ONE, Brilliance iCT, Discovery CT750 HD and Somatom Definition Flash) for cardiac imaging in people with suspected or known coronary artery disease in whom imaging is difficult with earlier generation CT scanners 2012