Heroes with Heart Disease

Why USAF Aircrew Do Not Die from Heart Disease

Right Care Initiative Virtual University of Best Practices - 23 Feb 2021

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Integrity ★ Service ★ Excellence

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Disclosure Information

Lt Col Eddie Davenport

- **I have no financial relationships to disclose.**
- **I will not discuss off-label use and/or investigational use in my presentation.**
- **The views expressed are those of the author and do not necessarily reflect the official policy or position of the Air Force, the Department of Defense, or the U.S. Government.**

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Cardiovascular Disease Background

- **CVD is the leading cause of global death in men and women**
  - **#1 listed cause of death on pilots and astronauts in the world.**
  - **17.8 million deaths a year,**
  - **Leading cost of aircraft diversion on Airlines, over 200 a day average cost $38,000**
- **Not a disease of old age**
  - **62% of those with CVD are under the age of 65**
  - **Most common cause of sudden death in Active Duty Military**
- **Modes of presentation**
  - **Sudden cardiac death**
  - **Myocardial infarction**
  - **Ischemic arrhythmias**
- **50% of those who die do so within 1 hour of symptom onset**
  - **25% due to sudden cardiac death**

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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 abnormal
  - **FCI** = initial pilot training, **FCII** = trained asset, **FCIII** = non-pilot duties
- **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.

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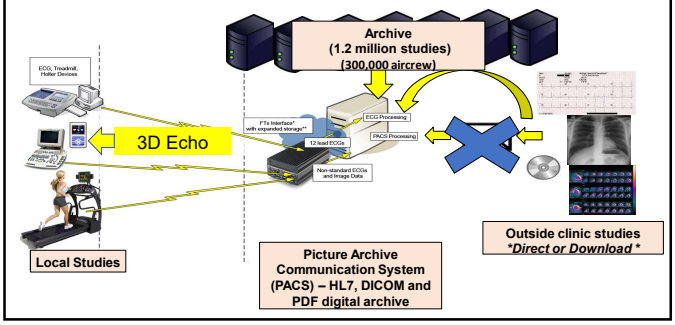
Evidence Based Aerospace Cardiology



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Evidence Based MISSION

- Knowledge of flight physiology
- Clinical knowledge / published data
- ACC/AHA Guidelines for Athletes
- *Analysis of the USAFSAM Database*

•Serial data gathered over decades to study natural history of progression and effect on USAF MILITARY AEROMEDICAL outcomes

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International Consensus

- Seven countries in North America and Europe. NATO and Partners for Peace Countries.
- New partners…
  - Army, Navy, Marines, Coast Guard
  - FAA, EASA
  - NASA, ESA, Boeing, SpaceX

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Aerospace Cardiology WORLD EXPERTS

- NATO - The Human Factor Medicine Panel

Aviation Cardiology Working Group

- Wg Cdr Joanna D'Arcy (UK) - Chairman
- Lt Col Eddie Davenport (USA) - Chairman
- Dr Gary Gray (Canada)
- Col Dr Olivier Manen (France)
- Lt Col Dr Norbert Guettler (Germany)
- Dr Rienk Rienks (Netherlands)
- Maj Denis Bron (Switzerland)
- Maj Dr Thomas Syburra (Switzerland)
- Wg Cdr Edward Nicol (UK) -

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Aerospace Cardiology

Where we have been….

- Data presented at >10 international conferences
- AsMA, ICASM, ESC, ETS, ACC, AHA. NATO, NASA, FAA, ECAM, ESA
- Early repolarization, CAC, LBBB, CAD with zero risk factors
- A-fib return to high performance, CAD return to high performance…

Where we are going….

- Emerging Cardiovascular Imaging
- Emerging Cardiovascular Treatment
- **From a consensus to GUIDELINES.**

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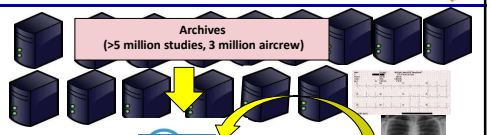
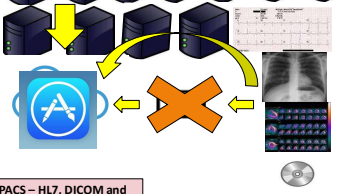
International Evidence Based Cardiology





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	Class 1 Medical Event	Class 2 Medical Event	Class 3 Medical Event	Class 4 Medical Event
	Minimal impact on mission	May result in a mission abort or compromised effectiveness	Likely to result in a flight safety hazard or compromise	Likely to result in a flight safety critical event
	May result in a deleterious effect on the health of the individual aircrew but minimal effect on performance	Aircrew able to continue duties with minor to moderate performance compromise.	Major decrement in performance	Total acute incapacitation (may include sudden death)
	Requires routine periodic medical follow-up	Requires medical attention	May require immediate medical attention	Requires immediate advanced medical care
PILOTS, COPILOTS				
Likely >2%/yr				
Possible 1-2%/yr				
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				
NAVIGATORS, FLIGHT ENGINEER, FLIGHT CONTROLLERS				
Likely >2%/yr				
Possible 1-2%/yr				
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				
FLIGHT ATTENDANTS LOADMASTERS				
Likely >2%/yr				
Possible 1-2%/yr				
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				

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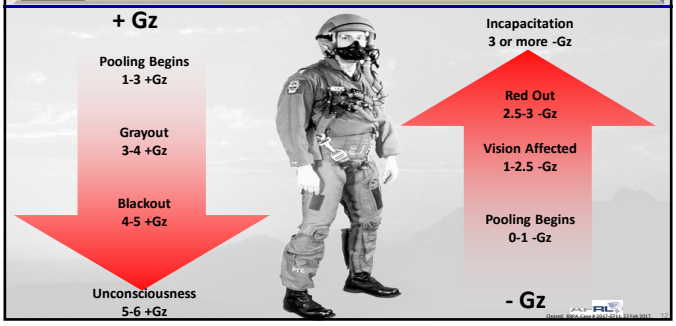
Cardiovascular Effects



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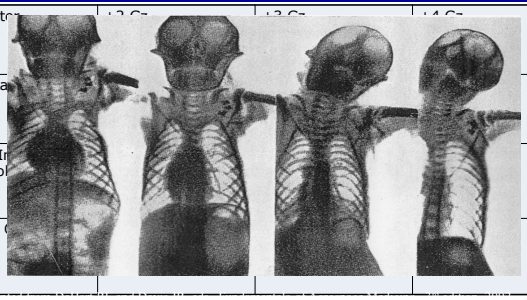
Effect of 2, 3, and 4 +Gz on Selected Physiologic Parameters

Parameter	+2 Gz	+3 Gz	+4 Gz
Heart Rate			
Stroke Index (ml/stroke)			
Cardiac Output			



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Flight Disposition Process

- Determine threshold of acceptable risk
  - <1% / year
- Determine event horizon / timeline
  - 10-20 years
- Determine aeromedical events of concern
  - Symptoms precluding mission completion
  - Consider impact of standard-of-care medical therapy and advances in technology / new tests
  - Apply special considerations (high +Gz, mission duration, single / dual pilot, ejection seat) & treatment effects

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Screening for CVD in Aircrew

- Despite better overall health of aviators, CVD still a valid concern
- Autopsy study in 710 commercial pilots[1]
  - Atherosclerosis found in 69%
  - Severe disease in 2.5%
- Review of cardiac events in U.S. aviators[2]
  - MI, angina, and sudden cardiac death over 5-year period
    - Average event rate 0.02%
  - While event rate low, presentation more concerning
    - Myocardial infarction and sudden cardiac death in 82%
      - NO WARNING

[1]Booze et al. Aviat Space Environ Med. 1987
[2]Osswald et al. Aviat Space Environ Med. 1996

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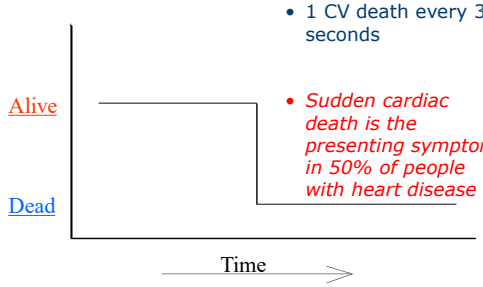
The Basic Problem of Cardiovascular Disease

- 1 CV death every 33 seconds
- *Sudden cardiac death is the presenting symptom in 50% of people with heart disease*



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Should we screen with a Stress Test?

Test with 80% Sensitivity, 90% Specificity
Population 20,000 subjects,
***5% prevalence* CAD**

	Significant CAD (5% of 20,000 = 1000)	No Significant CAD (95% of 20,000 = 19,000)
Abnormal Test	800 (TP) (80% of 1000)	1,900 (FP)
Normal Test	200 (FN)	17,100 (TN) (90% of 19,000)

PPV* = TP/(TP+FP) = *30%
NPV* =(TN/(TN+FN) = *98%

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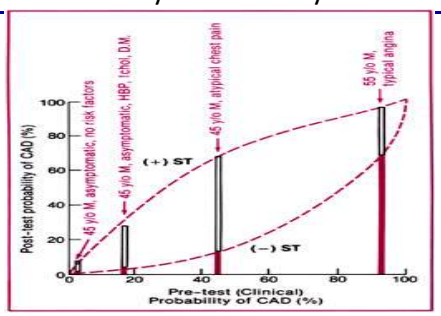
Bayesian Theory



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USAF ECG Library Database – Screening Analysis

- 903 aviators with treadmill, thallium, and cardiac fluoroscopy for coronary artery calcification
- Mean age 43.7 yr, mean f/u 11.8 yr
- Sensitivity, specificity, positive predictive value, and negative predictive value for moderate or greater CAD (≥50%) and severe CAD (> 70%)
- Average annual event rates at 2/5 yr

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Noninvasive Tests

For detection of moderate or greater CAD (≥50% stenosis)

	Treadmill	Thallium	Fluoroscopy
•Sens	54%	55%	68%
•Spec	49%	62%	71%
•PPV	16%	21%	29%
•NPV	86%	89%	93%

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Noninvasive Tests

Annual cardiac event rate (cardiac death, first nonfatal MI, or first delayed coronary revascularization) at 5 yr:

	Treadmill	Thallium	Fluoroscopy
Abnormal test	0.5%/yr	0.6%/yr	1.3%/yr
Normal test	0.5%/yr	0.5%/yr	0.1%/yr

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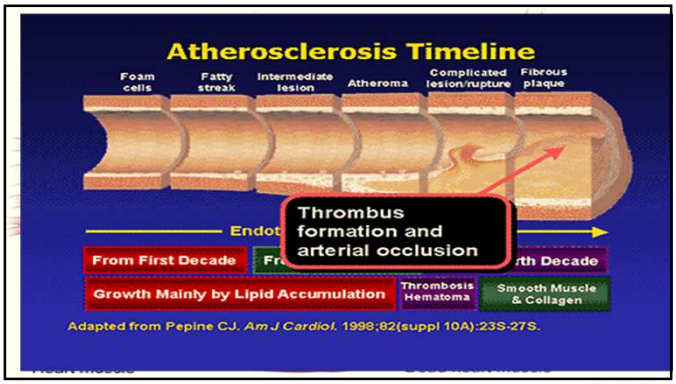

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Coronary Artery Angiography Annual Event Rates

- **Calcium**

Negative	Positive	*P value*
0.66%	1.8%	0.006

- **Max Lesion**

<50%	>50%	
0.80%	2.17%	0.007

- **Aggregate**

<50	50-120	>120	
• 0.6	1.1%	3.0%	0.0002

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CAD in Aviators is DEFINED BY ANATOMY

- **Fluoroscopy**

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

- **Max Lesion**

<50%	>50%

- **Aggregate**

WAIVERABLE		DISQUALIFIED
Mild	Moderate	Severe
<50	50-120	>120
0.6%	1.1%	3%

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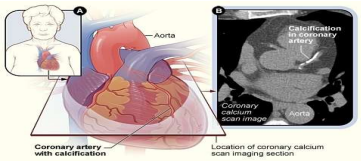
Detection of Coronary Artery Calcium by Computed Tomography



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

Rozanski et al., JACC 2007

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%

Note: All with a normal Stress test; Annual Event Rates jump to > 20% with a positive CAC AND positive stress test!!!

Comparison of Event Rates

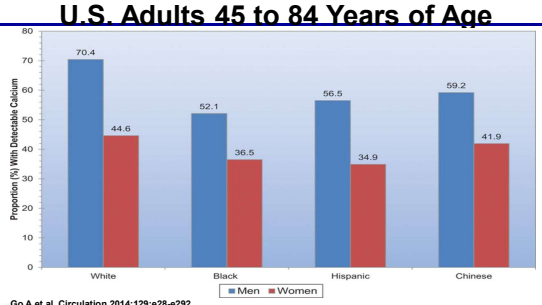
Angiography Summed Score	CAC Score (literature)
• Min CAD (aggregate < 50%): – ***0.5% to 1.0%/yr*** – Annual Re-eval	• CAC 0-9: **0.00 %/yr**
• Mod CAD (aggregate 50-120, no lesion > 70): – ***1.0% to 2.0%/yr*** – Annual Re-eval; cath q **5 yr (NEW)**	• CAC 10-100: **0.5% to 1.0%/yr** • CAC 101-399: **1.0% to 2.0 %/yr**
• Sev CAD (aggregate > 120 or lesion > 70): – ***3.0% +/yr; DQ – no waiver***	• 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***

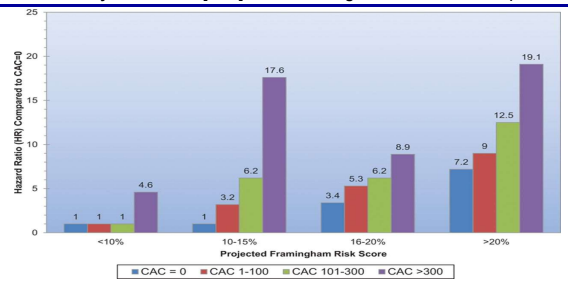
Both measures are predictive of future events in aviators with asymptomatic coronary artery disease

Prevalence (%) of Coronary Calcium: U.S. Adults 45 to 84 Years of Age



Go A et al. Circulation 2014;129:e28-e292

Hazard Ratios (HR) for Coronary Heart Disease Events Associated with Coronary Calcium Scores: U.S. Adults (reference group, coronary artery calcification [CAC]=0 and Framingham Risk Score <10%)



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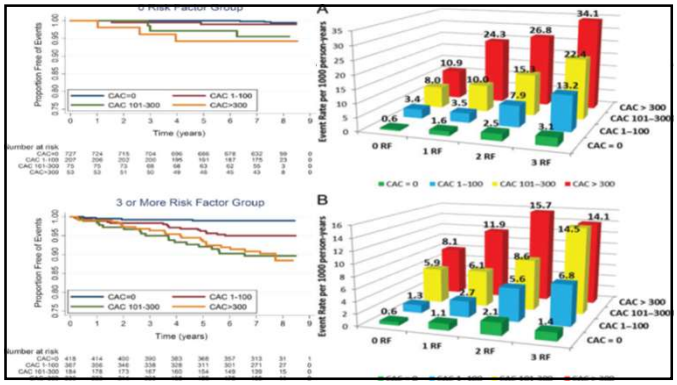

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CLASS I

1. Global risk scores (such as the Framingham Risk Score [FRS]) that use multiple traditional cardiovascular risk factors should be obtained for risk assessment in all asymptomatic adults without a clinical history of CHD. These scores are useful for combining individual risk factor measurements into a single quantitative estimate of risk that can be used to target preventive interventions (25). (*Level of Evidence: B*)

CLASS IIa

1. Measurement of CAC is reasonable for cardiovascular risk assessment in asymptomatic adults at intermediate risk (10% to 20% 10-year risk) (18,348). (*Level of Evidence: B*)

CLASS IIb

1. An exercise ECG may be considered for cardiovascular risk assessment in intermediate-risk asymptomatic adults (including sedentary adults considering starting a vigorous exercise program), particularly when attention is paid to non-ECG markers such as exercise capacity (296–298). (*Level of Evidence: B*)

CLASS IIb

1. Measurement of CAC may be reasonable for cardiovascular risk assessment in persons at low to intermediate risk (6% to 10% 10-year risk) (348–350). (*Level of Evidence: B*)

CLASS IIb

1. A resting ECG may be considered for cardiovascular risk assessment in asymptomatic adults without hypertension or diabetes (202-204). (*Level of Evidence: C*)

Cleared, 88PA Case # 2017-0711, 22 Feb 2017 32

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Proposed Aviator
Cardiovascular Screening Algorithm

Cleared, 88PA Case # 2017-0711, 22 Feb 2017 33

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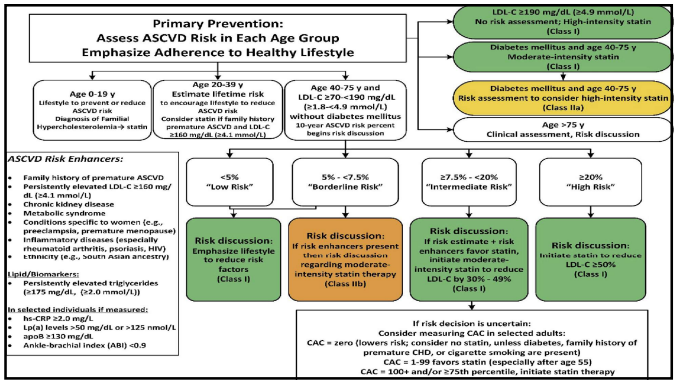

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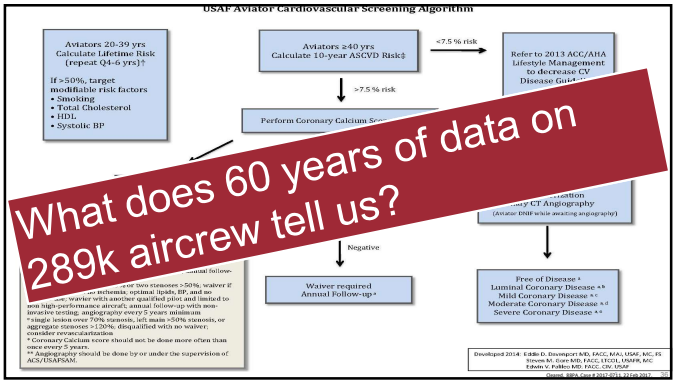

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Risk Factors associated with severe CAD

- Average BMI 28 kg/m^2
- Average HDL 34 mg/dL (0.9 mmol/L) Fasting Glucose 105 mg/dL
- Total Cholesterol average 198 (5.1 mmol/L)
- LDL average 136 (3.5 mmol/L), TG average 140 (1.6 mmol/L)
- Average SBP 132 mmHg
- Family history in 60%
- Average PT test score 85% = good

- NO RISK FACTORS = 2 out of 172 (one had SCD); no coffee or EtOH
- Risk if optimal risk factors = 0.007%

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Risk Factors at Diagnosis

FACTOR	MILD	MODERATE	SEVERE / REVASC
Systolic blood pressure (mmHg)			132
Body mass index (kg/m^2)			28
LDL / TG (mg/dL)			136 / 140
HDL (mg/dL)			34
Family history			60%
PT test score			85
Tobacco (current)			17%
Alcohol – 5/wk			8%
Coffee – 5/wk			20%

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Risk Factors

- Coffee and Alcohol?
  - Positive CAD rarely did both daily
    - Daily alcohol and coffee – ZERO revascularization if mild or moderate CAD
    - If started after revascularization then associated with normal/improved 3/5 year cath, significant increase in HDL.
    - Proven benefits of both coffee and Alcohol, only in moderation, with rather large increases in morbidity with excessive use. Exercise is much better…
- Exercise / Diet – to get BMI<25 kg/m2 and HDL>50
  - Exercise plus low HDL – some "over exercise" – higher risk CAD!
  - Low HDL raised by DIET and Exercise = decrease repeat revasc
  - NO consistent evidence of benefit raising HDL pharmacologically
  - More Vigorous 75-150 min/week is best

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Don't Die from CAD

- Risk Factor Control
- Exercise
- Coffee
- Alcohol
- STRESS
  - Financial – what are we working for?
  - Emotional – Joy, Integrity, Grace – 50% reduction in all cause mortality

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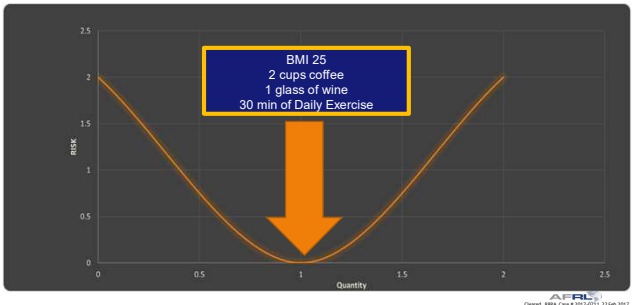
Your Story…



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Slide 42

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