# Captain Suffers Sudden Cardiac Death While Performing Physical Fitness Training - Mississippi

## Executive Summary

On May 6, 2015, a 44-year-old male career captain (the Captain) responded to a carbon monoxide (CO) call. After returning to the station, the Captain played basketball for about 1 hour as part of the fire department's physical fitness program. He stopped playing due to a leg cramp, but when he resumed play, he collapsed. Crewmembers began cardiopulmonary resuscitation (CPR) as Dispatch was notified. An automated external defibrillator was applied and two shocks were administered. The ambulance arrived and paramedics began advanced life support. A cardiac monitor revealed asystole (no heart beat) as the ambulance transported the Captain to the emergency department (ED). Inside the ED, cardiac resuscitation efforts continued for 36 minutes. At 1937 hours, with no change in his clinical status, the Captain was pronounced dead.

The death certificate, completed by the County Medical Examiner, and the autopsy, completed by the State Medical Examiner, listed "hypertensive and atherosclerotic cardiovascular disease" as the cause of death. In 2012 the Captain experienced angina and was found to have a 99% blockage of his left anterior descending coronary artery. The blockage was successfully opened with angioplasty and a stent was placed. Since that time, the Captain has been followed by a cardiologist for his coronary heart disease (CHD). Given the Captain's underlying CHD, NIOSH investigators concluded that the physical stress of fitness training probably triggered a cardiac arrhythmia, which ultimately resulted in his death.

## Key Recommendations

- *Provide preplacement and annual medical evaluations to all fire fighters consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to identify fire fighters at increased risk CHD*
- *Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the components of NFPA 1582*

The following recommendations would not have prevented the Captain's death, but NIOSH investigators include them to address general safety and health issues:

- *Provide fire fighters with medical clearance to wear a self-contained breathing apparatus (SCBA) as part of the fire department's medical evaluation program*
- *Discontinue routine hepatitis C virus (HCV) and human immunodeficiency virus (HIV) screening at routine exams*
- *Undertake prostate screening only after a discussion between the fire department physician and the fire fighter regarding the pros and cons of this testing*

# *Captain Suffers Sudden Cardiac Death While Performing Physical Fitness Training - Mississippi*

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH "Fire Fighter Fatality Investigation and Prevention Program" which examines line-of-duty-deaths or on duty deaths of fire fighters to assist fire departments, fire fighters, the fire service and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with State or Federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the victim, the fire department or those interviewed. The NIOSH report's summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency's recommendations and is not intended to be definitive for purposes of determining any claim or benefit.

For further information, visit the program website at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).

2015
12

Death in the line of duty...

NIOSH Fire Fighter Fatality Investigation and Prevention Program

A summary of a NIOSH fire fighter fatality investigation

October 22, 2015

# Captain Suffers Sudden Cardiac Death While Performing Physical Fitness Training - Mississippi

## Introduction

On May 6, 2015, a 44-year-old male career Captain suffered sudden cardiac death while participating in physical fitness training. NIOSH was notified of the fatality on May 18, 2015, by the U.S. Fire Administration. NIOSH contacted the affected fire department on May 18, 2015, to gather additional information, and on July 14, 2015, to initiate the investigation. On July 27, 2015, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Prevention and Investigation Program conducted an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- Battalion Chief
- Crew members
- Captain's fiancé

NIOSH personnel reviewed the following documents:

- Fire department standard operating procedures
- Fire department annual report for 2014
- Witness statements
- Emergency medical service (ambulance) report
- Emergency department report
- Death certificate
- Autopsy report
- Primary care physician records

## Investigation

On May 6, 2015, the Captain arrived for duty at about 0700 hours for his 24-hour shift. During the day, the Captain performed station duties including apparatus and equipment checks, station cleanup, and 2-minute self-contained breathing apparatus (SCBA) dressing drills. At 1708 hours, the fire department was dispatched for a residential CO call. On-scene, the Captain stood outside, while members of his crew investigated the home. After no CO was detected using a 4-gas real time instrument, his crew returned to service at 1724 hours. After returning to the fire station, the Captain drove to Station 3 to play basketball as a part of the fire department's physical fitness program.

After playing half-court basketball for about 1 hour, the Captain complained of a leg cramp and stopped playing for about 30 seconds. When he resumed playing, he collapsed. Crewmembers assessed the Captain and found him unresponsive with no pulse or respirations. CPR was begun as Dispatch was notified and an ambulance was dispatched (1840 hours). An automated external defibrillator was retrieved from a Station 3 engine; when placed on the Captain, a shockable heart rhythm was

identified. Two shocks were administered without positive change in the Captain's clinical status. Oxygen was administered via bag-valve-mask as CPR continued.

The ambulance arrived at 1844 hours. A cardiac monitor revealed asystole (no heart beat), an intravenous line was placed, and cardiac resuscitation medications were administered. Intubation was attempted twice without success. Ventilations via bag-valve-mask and CPR continued as the ambulance departed the scene at 1857 hours en-route to the ED.

The ambulance arrived at the ED at 1901 hours. Inside the ED, advanced life support continued, including intubation with proper tube placement confirmed by capnography [Neumar et al. 2010]. Despite 36 minutes of cardiac resuscitation efforts in the ED, the Captain was pronounced dead by the attending physician at 1937 hours.

## Medical Findings

The death certificate, completed by the County Medical Examiner, and the autopsy, completed by the State Medical Examiner, listed "hypertensive and atherosclerotic cardiovascular disease" as the cause of death. The Captain had a history of the following pertinent medical problems:

Coronary Heart Disease – diagnosed in October 2012 after having angina, a positive imaging exercise stress test, and a cardiac catheterization showing a 99% blockage in his left anterior descending coronary artery. He underwent angioplasty and a stent was placed. During his work-up he was found to have mild left ventricular hypertrophy (LVH), although he maintained a normal left ventricular ejection fraction as determined by cardiac catheterization, gated blood pool scan, and echocardiography in October 2012. In September 2013, the Captain was cleared for full duty by his treating cardiologist. In June 2014, a resting electrocardiogram (EKG) showed some new T wave changes suggesting possible inferior ischemia. During a subsequent exercise stress test the Captain exercised for almost 10 minutes and reached 11.4 metabolic equivalents (METS) on the Bruce protocol before stopping when he reached 85% of his target heart rate. The test was negative for angina, ischemic changes on EKG, and arrhythmias, but he did show an exaggerated systolic blood pressure. Following his angioplasty/stent placement in 2012, the Captain was maintained on a beta-blocker and anti-platelet agents (baby aspirin and Plavix®).

Pre-Diabetes Mellitus – as determined by fasting blood sugars ranging from 105 to 115 milligram per deciliter (mg/dL) (normal 70-105) since 2013. His last glucose reading in January 2015 was 113 mg/dL and he was encouraged to lose weight.

Stage II Hypertension – diagnosed in 2001; anti-hypertensive medications lowered his blood pressure to Stage I levels (systolic 140-159 millimeters of mercury [mmHg] or diastolic 90-99 mmHg). His last blood pressure reading in March 2015 was 150/97 mmHg.

Hyperlipidemia – diagnosed in 2006, with good control on statin medication.

Metabolic syndrome – the Captain had four of the five conditions defining metabolic syndrome: hypertriglyceridemia, low HDL-C (< 40 mg/dL), hypertension (> 135/85 mmHg), and elevated fasting glucose (> 110 mg/dL) [NFPA 2013a].

Family history of CHD – The Captain's mother passed away prior to age 60 due to heart disease.

Obesity – The Captain was 74 inches tall and weighed 278 pounds, giving him a body mass index of 35.7 kilograms per meters squared [CDC 2015]. Diet and exercise had been recommended by his primary care physician.

## Fire Department

At the time of the NIOSH investigation, the fire department consisted of three fire stations with 32 career uniformed personnel. It served 7,500 residents in a geographic area of 14 square miles. In 2014, the fire department responded to 1,000 incidents: 36 structure fire calls, 27 vegetation fire calls, 22 vehicle fire calls, 27 other fire calls, 66 alarm calls, 23 hazardous condition calls, 673 emergency medical calls, and 126 other calls.

## Employment, Membership, Training, and Experience

The fire department requires new career fire fighter applicants to be 18 years of age; have a valid state driver's license; and pass a physical agility test (see Appendix B) and an oral interview prior to being offered conditional employment. The new hire must then pass a preplacement medical evaluation (described below) and a drug screening. The new member is on probation for 6 months. The member then attends the 6-week State Fire Academy to be trained to the NFPA 1001 Fire Fighter I and II level. The member receives emergency medical technician training at a local community college. The State requires career fire fighter candidates to meet the State Minimum Standards and Certification Board guideline, which is the National Fire Protection Association (NFPA) 1001, *Standard for Fire Fighter Professional Qualifications* [NFPA 2013a]. The Captain was certified as a fire fighter II, driver/operator, emergency medical technician-basic, fire officer II, fire investigator, fire service instructor, safety officer, airport fire fighter, hazardous materials technician, and in technical rescue. He had 20 years of fire fighting experience and was promoted to Captain in September 2007.

## Preplacement and Annual Medical Evaluations/Return to Work Medical Evaluations

The fire department requires preplacement medical evaluations for all applicants conducted by a fire department contract physician. Components of this evaluation include the following:

- Complete medical history
- Physical examination (including vital signs – height, weight, blood pressure, pulse, and respirations)
- Urine drug screen

## *Captain Suffers Sudden Cardiac Death While Performing Physical Fitness Training - Mississippi*

Periodic medical evaluations ("Healthy You Exams") are required for members with the frequency based on the age of the fire fighter (see below). The components of the evaluation are determined by the fire department insurance carrier and are conducted by the member's primary care physician. These medical evaluations are not conducted for medical clearance purposes and the results are not shared with the fire department contract physician. The Captain's last fire department medical evaluation was in August 2013 where his CHD was noted. The Captain was last medically cleared for duty in September 2013 by his cardiologist. Medical clearance to wear a respirator is not required.

Men ages 18-39

- Blood pressure measurement:
  - every 2 years if less than 120/80 mmHg
  - yearly if systolic is 120 to 139 mmHg or diastolic is 80 to 89 mmHg
- Type 2 diabetes mellitus, screening with a fasting blood glucose every 3 years
- Lipid (cholesterol and triglyceride) blood screening every 5 years
- Vision testing every 5 to 10 years if no risk factors for eye disease
- Immunizations (tetanus/diphtheria/pertussis booster; measles, mumps, rubella; chickenpox, flu [seasonal], hepatitis A, hepatitis B, *haemophilus influenza* Type B, human papillomavirus, meningococcal, and pneumococcal) per Centers for Disease Control and Prevention guidelines
- Hepatitis C screening at routine exams
- HIV screening at routine exams

Men ages 40-49

- Same components as Men ages 18-39
- Prostate cancer (digital rectal exam and prostate-specific antigen) screening beginning at age 45
- Vision testing every 2 to 4 years if no risk factors for eye disease

Men ages 50-64

- Same components as Men ages 40-49
- Colorectal cancer screening (flexible sigmoidoscopy, colonoscopy, double-contrast barium enema, fecal occult blood test, fecal immunochemical test, or stool DNA test) per American Cancer Society guidelines
- Lung cancer screening with a high resolution CT scan yearly for adults age 55 to 80 with a 30 pack-year history of smoking

## Wellness/Fitness Programs

The fire department has a mandatory wellness/fitness program, and exercise equipment is available in the fire stations. Playing basketball is included in the fitness program. A candidate physical agility test is required for all fire fighter applicants (Appendix B) followed by quarterly physical agility tests for members (Appendix C). The Captain participated in the fire department's mandatory wellness/fitness program by walking, running, and playing basketball on a regular basis. The Captain passed his last physical agility test in March 2015.

# DISCUSSION

**Coronary Heart Disease and Sudden Cardiac Events**

In the United States, atherosclerotic CHD is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development include age older than 45, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes [NHLBI 2014; AHA 2015]. The Captain had known CHD prior to this incident and severe CHD on autopsy. He was unable to reach treatment goals for two of his modifiable CHD risk factors (high blood pressure and obesity).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2008]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion [Shah 1997]. Heart attacks (myocardial infarctions) typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply [Fuster et al. 1992]. This sudden blockage is primarily due to blood clots (thromboses) forming on top of atherosclerotic plaques. Establishing a recent (acute) heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes, or coronary artery thrombus. In this case, the Captain's cardiac enzymes were not tested, no acute coronary artery thrombus was revealed at autopsy, and he did not have a heart rhythm to conduct an EKG. Given the Captain's lack of angina, a cardiac arrhythmia (discussed below), rather than a heart attack, was the likely cause of his sudden cardiac death.

**Primary Arrhythmia**

A primary cardiac arrhythmia (e.g., ventricular tachycardia/fibrillation) was likely responsible for the Captain's sudden cardiac death. Risk factors for arrhythmias include heart disease, heart attack, dietary supplements, smoking, alcohol, drug abuse, medications, diabetes, and hyperthyroidism [AHA 2014; Mayo Clinic 2015]. The Captain had CHD and LVH. Both these conditions increase the risk for a primary arrhythmia [AHA 2014].

**Left Ventricular Hypertrophy**

On autopsy, and during the Captain's echocardiogram in 2012, the Captain was found to have LVH, which increases the risk for sudden cardiac death [Levy et al. 1990]. Hypertrophy of the heart's left ventricle is a relatively common finding among individuals with long-standing hypertension, a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle) [Siegel 1997]. The Captain's LVH was probably due to his hypertension and/or chronic ischemia.

**Physiological Stress of Firefighting**

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks and sudden cardiac death [Mittleman et al. 1993; Willich et al. 1993; Albert et al. 2000]. Sudden cardiac events in fire fighters have been associated with alarm response, fire suppression, and heavy exertion during training (including physical fitness training) [Kales et al. 2003; Kales et al. 2007; NIOSH 2007]. The Captain had played basketball for 1 hour. This

activity expended about 8 metabolic equivalents, which is considered heavy physical activity [Ainsworth et al. 2011].

**Occupational Medical Standards for Structural Fire Fighters**

To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the National Fire Protection Association developed NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments* [NFPA 2013b]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. The Captain had several conditions addressed by NFPA 1582: 1) CHD, 2) Stage II hypertension controlled only to Stage 1, 3) undiagnosed metabolic syndrome, and 4) beta-blocker medication.

**Coronary Heart Disease.** The Captain's underlying CHD was identified in 2012. NFPA 1582 states that a history of myocardial infarction, coronary artery bypass surgery, coronary angioplasty with stent placement, or similar procedures compromise the member's ability to safely perform 8 of the 13 essential job tasks of being a fire fighter. NFPA 1582 recommends that a fire fighter with CHD be restricted from full duty if any one of the following are present:
(1) current angina pectoris even if relieved by medication
(2) persistent significant stenosis in any coronary artery (> 70 percent lumen diameter narrowing) following treatment
(3) lower than normal left ventricular ejection fraction as measured by radionuclide scan, contrast ventriculography, or echocardiography
(4) maximal exercise tolerance of less than 12 METs
(5) exercise-induced ischemia or ventricular arrhythmias observed by radionuclide stress test during an evaluation reaching a workload of at least 12 METs
(6) history of myocardial infarction, angina, or coronary artery disease with persistence of modifiable risk factor(s) for acute coronary plaque rupture (e.g., tobacco use, hypertension despite treatment, hypercholesterolemia with cholesterol greater than or equal to 180, low density lipoproteins greater than or equal to 100 despite treatment, or glycosylated hemoglobin greater than 7 despite exercise and/or weight reduction).

The Captain did not reach 12 METs on his most recent exercise stress test, had persistent Stage I hypertension despite treatment, and was not tested for glycosylated hemoglobin. Therefore, NFPA 1582 would have recommended restricted duty.

**Hypertension.** The Captain fluctuated between Stage I and Stage II hypertension. NFPA 1582 suggests that members with stage I hypertension be referred to their primary care physician to ensure that their blood pressure is controlled and to determine whether screening for end organ damage is indicated [NFPA 2013b]. NFPA considers that Stage II hypertension (systolic ≥160 mmHg or diastolic ≥ 100 mmHg) or end organ damage (retinopathy, nephropathy, neuropathy, or vascular/cardiac complications) compromises the member's ability to safely perform five essential job tasks of being a fire fighter. The Captain's hypertension was diagnosed in 2001 and was intermittently controlled with medication, but he did not have a complete work-up for end organ damage. The Captain's most recent

blood pressure readings were elevated. Therefore, according to NFPA 1582, the Captain's hypertension should have resulted in work restrictions [NFPA 2013b].

**Metabolic Syndrome.** Metabolic syndrome is associated with reduced aerobic capacity and increased risk for cardiovascular ischemic disease, diabetes, and hypertension. NFPA 1582 recommends members with metabolic syndrome undergo an imaging exercise stress test. If the results are abnormal or the member is unable to achieve an aerobic capacity of 12 METs, the member should be given restrictions due to their inability to safely perform many essential job tasks [NFPA 2013b]. The Captain had a non-imaging exercise stress test in June 2014. He achieved 11.4 METs, but the test was stopped because he reached 85% of his target heart rate. Perhaps, if the Captain was asked to do a symptom-limiting test, he would have been able to meet the 12 MET requirement.

**Beta-Blocker Medication.** NFPA 1582 considers use of beta-blockers to compromise the member's ability to safely perform essential job tasks such as the following: 1) wearing fire protective ensemble that is encapsulating and insulated, which will result in significant fluid loss that frequently progresses to clinical dehydration and can elevate core temperature to levels exceeding 102.2ºF; and 2) wearing personal protective ensemble and SCBA, climbing ladders, operating from heights, walking or crawling in the dark along narrow and uneven surfaces, and operating in proximity to electrical power lines and/or other hazards due to risk for dehydration, electrolyte disorders, lethargy, and disequilibrium, and the physician shall report applicable job limitations to the fire department [NFPA 2013b].

In summary, according to NFPA 1582, the Captain had multiple medical conditions that should have resulted in restricted duty.

# Recommendations

***Recommendation #1: Provide preplacement and annual medical evaluations to all fire fighters in accordance with NFPA 1582,* Standard on Comprehensive Occupational Medical Program for Fire Departments*, to identify fire fighters at increased risk for CHD*.**

Discussion: We applaud the fire department for providing preplacement and periodic medical evaluations. However, the fire department's medical program could be strengthened by 1) expanding the components of the preplacement evaluations, and 2) requiring annual medical evaluations for members. Guidance regarding the content and frequency of these medical evaluations can be found in NFPA 1582 and in the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) *Fire Service Joint Labor Management Wellness/Fitness Initiative* [IAFF, IAFC 2008; NFPA 2013b]. These evaluations are performed to determine fire fighters' medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. Following this recommendation will require significant resources and may be difficult to implement. In addition, the fire department has no legal obligation to follow the NFPA standard or the IAFF/IAFC guideline. Nonetheless, according to fire department officials, in the fall of 2015 the department will begin requiring exercise stress tests for fire fighters at increased risk for CHD.

***Recommendation #2: Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.***

Discussion: NFPA 1582 requires that the fire department designate a physician responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty [NFPA 2013b]. The physician should review job descriptions and essential job tasks required for all fire department positions to understand the physiological and psychological demands of fire fighters and the environmental conditions under which they must perform, as well as the personal protective equipment they must wear during various types of emergency operations. Currently, the findings from the fire department periodic member medical evaluations ("Healthy You Exams") are not shared with the fire department contract physician. Thus, decisions regarding duty medical restrictions are made by the fire fighter's personal physician(s). It is unclear if fire fighter's personal physicians are familiar with the recommendations of NFPA 1982 [NFPA 2013b].

The following recommendations would not have prevented the Captain's death, but NIOSH investigators include them to address general safety and health issues:

***Recommendation #3: Provide fire fighters with medical clearance to wear SCBA as part of the fire department's medical evaluation program.***

Discussion: The Occupational Safety and Health Administration (OSHA) *Revised Respiratory Protection Standard* requires employers to provide medical evaluations and clearance for employees using respiratory protection [29 CFR 1910.134]. These clearance evaluations are required for private industry employees and only for public employees in states operating OSHA-approved state plans. Because Mississippi does not operate a state OSHA plan [OSHA 2015], the fire department is not required to provide medical evaluations for employees using respirators. However, we recommend voluntary compliance with this recommendation to improve fire fighter health and safety.

***Recommendation #4: Discontinue routine HCV and HIV screening at routine exams.***

Discussion: NFPA 1582 recommends a baseline screening upon joining the fire department, and then repeated when an occupational exposure occurs [NFPA 2013b]. Routinely conducting HCV and HIV testing for fire fighter with no risk factors or no reported exposures is an unnecessary expense for the fire department and possibly unnecessary burden for the individual due to the possibility of false positive test results leading to unnecessary followup. Rather, HCV and/or HIV testing should be conducted when the infection control officer has determined that a potential infectious exposure has occurred.

## *Captain Suffers Sudden Cardiac Death While Performing Physical Fitness Training - Mississippi*

***Recommendation #5: Undertake prostate screening only after a discussion between the fire department physician and the fire fighter regarding the pros and cons of this testing.***

Discussion: Prostate cancer is the second most common cancer in men in the United States. Although prostate cancer is very common, in many cases, the cancer does not grow or cause symptoms during a man's lifetime. Therefore, only a very small number of adult men benefit from screening.
The PSA test is commonly used to screen for prostate cancer, however, the test has several limitations. For example, PSA levels may be high in men with other types of prostate problems. This is called a "false-positive" result. False-positive results cause worry and anxiety and can lead to follow-up tests that aren't needed such as needle biopsies that can cause fever, infection, bleeding, urinary problems, and pain. Second, even if biopsy finds some prostate cancer cells, currently there is no way to tell if those cells will go on to cause a problem. This means that many non-harmful cancers are diagnosed. This is called "over diagnosis." Many men with prostate cancer found by the PSA test go on to get treated with surgery, radiation, or hormone therapy despite that fact that many of these cancers will not grow or cause health problems. This is called "overtreatment." Many treatments have complications including: 1) erectile dysfunction (impotence) from surgery, radiation therapy, or hormone therapy; 2) urinary incontinence from radiation therapy or surgery; 3) problems with bowel control from radiation therapy; and 4) a small risk of death and serious complications from surgery. Because of these limitations, all major medical organizations recommend against the routine PSA screening of asymptomatic men who are not at increased risk for prostate cancer [USPSTF 2012; AUA 2013a; AUA 2013b; AAFP 2015; ACS 2015; Wilt et al. 2015]. Rather, these organizations recommend that starting at age 50 a man discuss the benefits and harms of the test with his physician. Because many studies suggest that fire fighters may have an increased risk of prostate cancer, it may be helpful for them to start this discussion start at age 40 or 45 years [LeMasters et al. 2008; IARC 2010].

# References

AAFP [2015]. Choosing Wisely®: Prostate cancer screening using a prostate-specific antigen (PSA) Test or digital rectal exam. Leawood, KS: American Academy of Family Physicians. [http://www.aafp.org/patient-care/clinical-recommendations/all/cw-prostate-cancer.html]. Date accessed: September 2015.

ACS [2015]. Recommendations for prostate cancer early detection. Atlanta, GA: American Cancer Society. [http://www.cancer.org/cancer/prostatecancer/moreinformation/prostatecancerearlydetection/prostate-cancer-early-detection-acs-recommendations]. Date accessed: September 2015.

AHA [2014]. Understand your risk for arrhythmia. Dallas, TX: American Heart Association. [http://www.heart.org/HEARTORG/Conditions/Arrhythmia/UnderstandYourRiskforArrhythmia/Understand-Your-Risk-for-Arrhythmia_UCM_002024_Article.jsp]. Date accessed: September 2015.

AHA [2015]. Understand your risk of heart attack. Dallas, TX: American Heart Association. [http://www.heart.org/HEARTORG/Conditions/HeartAttack/UnderstandYourRiskofHeartAttack/Understand-Your-Risk-of-Heart-Attack_UCM_002040_Article.jsp]. Date accessed: September 2015.

AUA [2013a]. Early detection of prostate cancer. Linthicum, MD: American Urological Association. [https://www.auanet.org/about/policy-statements/early-detection-of-prostate-cancer.cfm]. Date accessed: September 2015.

AUA [2013b]. Early detection of prostate cancer: AUA Guideline. Linthicum, MD: American Urological Association. [https://www.auanet.org/education/guidelines/prostate-cancer-detection.cfm]. Date accessed: September 2015.

Albert CM, Mittleman MA, Chae CU, Lee IM, Hennekens CH, Manson JE [2000]. Triggering of sudden death from cardiac causes by vigorous exertion. N Engl J Med *343*(19):1355–1361.

CDC (Centers for Disease Control and Prevention) [2015]. Assessing your weight. [http://www.cdc.gov/healthyweight/assessing/index.html]. Date accessed: September 2015.

CFR. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

Fuster V, Badimon L, Badimon JJ, Chesebro JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. N Engl J Med *326*(4):242–250.

Gibbons RJ, Balady GJ, Bricker JT, Chaitman BR, Fletcher GF, Froelicher VF, Mark DB, McCallister BD, Mooss AN, O'Reilly MG, Winters WL Jr., Antman EM, Alpert JS, Faxon DP, Fuster V, Gregoratos G, Hiratzka LF, Jacobs AK, Russell RO, Smith SC Jr [2002]. ACC/AHA 2002 guideline update for exercise testing: a report of the American College of Cardiology/ American Heart Association Task Force on Practice Guidelines. Circulation *106*(14):1883–1892.

IAFF, IAFC [2008]. The fire service joint labor management wellness/fitness initiative. 3rd ed. Washington, DC: International Association of Fire Fighters, International Association of Fire Chiefs.

IARC [2012]. Carcinogenicity of diesel-engine and gasoline-engine exhausts and some nitroarenes. Lancet/Oncology *13*(7):663-664.

Kales SN, Soteriades ES, Christoudias SG, Christiani DC [2003]. Firefighters and on-duty deaths from coronary heart disease: a case control study. Environ health: a global access science source. 2:14. [http://www.ehjournal.net/content/2/1/14]. Date accessed: September 2015.

Kales SN, Soteriades ES, Christophi CA, Christiani DC [2007]. Emergency duties and deaths from heart disease among fire fighters in the United States. N Engl J Med *356*(12):1207–1215.

LeMasters GK, Genaidy AM, Succop P, Deddens J, Sobeih T, Barriera-Viruet, H, Dunning, K, Lockey J [2006]. Cancer risk among firefighters: A review and meta-analysis of 32 studies. J Occup Environ Med *48*(11):1189–1202.

Levy D, Garrison RJ, Savage DD, Kannel WB, Castelli WP [1990]. Prognostic implications of echocardiographically determined left ventricular mass in the Framingham Heart Study. N Engl J Med *323*(24):1706–1707.

Libby P [2008]. The pathogenesis, prevention, and treatment of atherosclerosis. In: Fauci AS, Braunwald E, Kasper DL, Hauser SL, Longo DL, Jameson JL, Loscalzo J, eds. Harrison's principles of internal medicine. 17th ed. New York: McGraw-Hill, pp. 1501–1509.

Mayo Clinic [2015]. Heart arrhythmias. [http://www.mayoclinic.com/health/heart-arrhythmias/DS00290/METHOD=print&DSECTION=all]. Date accessed: September 2015.

Meyerburg RJ, Castellanos A [2008]. Cardiovascular collapse, cardiac arrest, and sudden cardiac death. In: Fauci AS, Braunwald E, Kasper DL, Hauser SL, Longo DL, Jameson JL, Loscalzo J, eds. Harrison's principles of internal medicine. 17th ed. New York: McGraw-Hill, pp. 1707–1713.

Mittleman MA, Maclure M, Tofler GH, Sherwood JB, Goldberg RJ, Muller JE [1993]. Triggering of acute myocardial infarction by heavy physical exertion. N Engl J Med *329*(23):1677–1683.

NFPA [2013a]. Standard for fire fighter professional qualifications. Quincy, MA: National Fire Protection Association. NFPA 1001.

NFPA [2013b]. Standard on comprehensive occupational medical program for fire departments. Quincy, MA: National Fire Protection Association. NFPA 1582.

NHLBI [2014]. Who is at risk for coronary artery disease? National Heart, Lung, and Blood Institute. [http://www.nhlbi.nih.gov/health/health-topics/topics/cad/atrisk.html]. Date accessed: September 2015.

NIOSH [2007]. NIOSH alert: preventing fire fighter fatalities due to heart attacks and other sudden cardiovascular events. [http://www.cdc.gov/niosh/docs/2007-133/]. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2007-133.

Neumar RW, Otto CW, Link MS, Kronick SL, Shuster M, Callaway CW, Kudenchuk PJ, Ornato JP, McNally B, Silvers SM, Passman RS, White RD, Hess EP, Tang W, Davis D, Sinz E, Morrison LJ [2010]. Part 8: Adult advanced cardiovascular life support. 2010 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Dallas, TX: American Heart Association.

OSHA (Occupational Safety and Health Administration) [2015]. State occupational safety and health plans. [http://www.osha.gov/dcsp/osp/index.html]. Date accessed: September 2015.

Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. Clin Cardiol *20*(11 Suppl2):II-38–44.

Siegel RJ [1997]. Myocardial hypertrophy. In: Bloom S, ed. Diagnostic criteria for cardiovascular pathology acquired diseases. Philadelphia, PA: Lippencott-Raven, pp. 55–57.

USPSTF [2012]. U.S. Preventive Services Task Force. Screening for prostate cancer: Recommendation Statement. Consumer's Guide.

Willich SN, Lewis M, Lowel H, Arntz HR, Schubert F, Schroder R [1993]. Physical exertion as a trigger of acute myocardial infarction. N Engl J Med *329*(23):1684–1690.

Wilt TJ, Harris RP, Qaseem A [2015]. Screening for cancer: advice for high-value care from the American College of Physicians. Ann Int Med *162*(10):718-731.

## Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component in Cincinnati, Ohio. Mr. Tommy Baldwin (MS) led the investigation and co-authored the report. Mr. Baldwin is a Safety and Occupational Health Specialist, a National Association of Fire Investigators (NAFI) Certified Fire and Explosion Investigator, an International Fire Service Accreditation Congress (IFSAC) Certified Fire Officer I, and a former Fire Chief and Emergency Medical Technician. Dr. Thomas Hales (MD, MPH) provided medical consultation and co-authored the report. Dr. Hales is a member of the NFPA Technical Committee on Occupational Safety and Health, and Vice-Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).

## Disclaimer

Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH). In addition, citations to Web sites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these Web sites.

# *Captain Suffers Sudden Cardiac Death While Performing Physical Fitness Training - Mississippi*

## Appendix A
## Autopsy Findings

- Coronary artery atherosclerosis
  - 90% focal narrowing in the anterior interventricular artery
  - 90% focal narrowing in the right coronary artery
  - Firm tan-white discoloration in posterior left ventricular wall consistent with myocardial fibrosis
  - Stent in the anterior interventricular artery
- Hypertensive heart disease
  - Cardiomegaly (heart weighed 580 grams [g]; predicted normal weight is 439 g [ranges between 333 g and 580 g as a function of sex, age, and body weight]) [Silver and Silver 2001]
  - Left Ventricular Hypertrophy
    - Left ventricle and interventricular thickening (1.5 centimeters [cm] and 1.8 cm respectively)
      - Normal at autopsy is 0.76–0.88 cm [Colucci and Braunwald 1997]
      - Normal by echocardiographic measurement is 0.6–1.0 cm [Connolly and Oh 2012]
- Normal cardiac valves
- No evidence of a thrombus (blood clot in the coronary arteries)
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Negative blood test for drugs and alcohol

## REFERENCES

Colucci WS, Braunwald E [1997]. Pathophysiology of heart failure. In: Braunwald, ed. Heart disease. 5th ed. Philadelphia, PA: W.B. Saunders Company, p. 401.

Connolly HM, Oh JK [2012]. Echocardiography. In: Bonow RO, Mann DL, Zipes DP, Libby P, Braunwald E, eds. Heart disease: a text of cardiovascular medicine. 9th ed. Vol. 1. Philadelphia, PA: Elsevier Saunders, p. 216.

Silver MM, Silver MD [2001]. Examination of the heart and of cardiovascular specimens in surgical pathology. In: Silver MD, Gotlieb AI, Schoen FJ, eds. Cardiovascular pathology. 3rd ed. Philadelphia, PA: Churchill Livingstone, pp. 8–9.

# *Captain Suffers Sudden Cardiac Death While Performing Physical Fitness Training - Mississippi*

## Appendix B
## Candidate Physical Agility Tests

The physical agility tests consist of the following components:

- Stair stepper. Timed event (3 minutes 20 seconds maximum)
- Hose drag
- Tool carry
- Ladder raise (hand over hand full extension and back)
- Forcible entry simulation (sledgehammer and tire)
- Search pattern
- Rescue drag
- Ceiling breach and pull

Maximum allowed time total for modified Candidate Physical Ability Test: 10 minutes 30 seconds.

# *Captain Suffers Sudden Cardiac Death While Performing Physical Fitness Training - Mississippi*

## Appendix C
## Quarterly Physical Agility Tests

The physical agility tests consist of endurance, upper body strength, and flexibility components:

- 1.5 mile run: 13:13-13:36 worth 70 points for members age 40-44
- Number of push-ups in 2 minutes: 40-42 worth 70 points for members age 40-44
- Number of sit-ups in 2 minutes: 35-36 worth 70 points for members age 40-44

Points are determined based on the member's age and test performance. A maximum number of points is 300 is attainable, but the minimum number of points to "pass" the quarterly test is age-based.