Captain Suffers Sudden Cardiac Death After Performing Physical Fitness Training - Mississippi

Executive Summary

On December 21, 2015, a 66-year-old male career captain (the Captain) performed fitness training by walking on a treadmill. After exercising for about 20 minutes, he ate dinner and went to take a shower. About 75 minutes later, a crew member found the Captain unresponsive in the shower room. Crewmembers checked for vital signs as Dispatch was notified. Due to signs of death, cardiopulmonary resuscitation (CPR) was not begun. Dispatch was notified. The ambulance arrived and paramedics applied a cardiac monitor. Asystole (no heart beat) was revealed. The Coroner was notified and responded. The Captain was pronounced dead at 2200 hours.

The death certificate was completed by the County Deputy Medical Examiner Investigator. A "visual" autopsy was completed by the Deputy State Medical Examiner. They listed "hypertensive cardiovascular disease" as the cause of death. The Captain had underlying coronary heart disease (CHD). NIOSH investigators concluded the exertion required to walk on the treadmill may have been sufficient to trigger a cardiac arrhythmia.

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*
- *Perform an annual physical ability evaluation*
- *Perform an autopsy on all on-duty fire fighter fatalities*

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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).

2016
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Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

A summary of a NIOSH fire fighter fatality investigation

November 10, 2016

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Introduction

On December 21, 2015, a 66-year-old male career Captain suffered sudden cardiac death about 1-2 hours after walking on a treadmill for his physical fitness training. NIOSH was notified of the fatality on December 28, 2015, by the U.S. Fire Administration. NIOSH contacted the affected fire department on January 4, 2016, to gather additional information and on July 22, 2016, to initiate the investigation. On August 1, 2016, 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, the NIOSH investigator interviewed the following people:

- Fire Chief
- Assistant Chief
- Crew members
- Captain's spouse

The NIOSH investigator reviewed the following documents:

- Fire department standard operating procedures
- Fire department annual report for 2015
- Emergency medical service (ambulance) report
- Death certificate
- Autopsy report
- Primary care physician records

Investigation

On December 21, 2015, the Captain arrived for duty at about 1730 hours for his 24-hour shift. After shift change, the Captain completed paperwork. He then went to the fire station's gym alone to exercise. He walked on the treadmill for about 20 minutes. He then ate dinner for about 30 minutes. After dinner, he went to take a shower. About 75 minutes later, a crewmember found the Captain lying supine on the shower room floor. He was unresponsive with no pulse or respirations and cool to the touch. A bag-valve-mask was used but it was not successful. Dispatch was notified (2120 hours) and an ambulance responded.

The ambulance arrived on the scene at 2128 hours. A cardiac monitor revealed asystole (no heart beat) and the paramedics noted signs of death (lividity and rigor mortis). The coroner was notified and responded. The Captain was pronounced dead at 2200 hours.

Medical Findings

The death certificate was completed by the County Deputy Medical Examiner Investigator. A "visual" autopsy was completed by the Deputy State Medical Examiner. Both listed "hypertensive

cardiovascular disease" as the cause of death. The Captain had a history of the following pertinent medical problems:

Stage I Hypertension – diagnosed in 2012; use of an anti-hypertensive medication and diet modification lowered his blood pressure to near normal levels. His last blood pressure reading in October 2015 was 136/84 millimeters of mercury.

Hyperlipidemia – diagnosed in February 2015 with elevated triglycerides and low level of high density lipoprotein. He had good control with diet modification. His last readings in October 2015 were normal.

Smoking – the Captain smoked 1 pack of small cigars per day for about 50 years.

Fire Department

At the time of the NIOSH investigation, the fire department consisted of three fire stations with 42 career uniformed personnel. It served 17,000 residents in a geographic area of 14 square miles.

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; be a county resident; have no felony convictions; pass a physical agility test (see Appendix B); pass a written examination; pass an oral interview with five fire department administrators; pass a background check; pass a drug and alcohol screen and a psychological evaluation prior to being offered conditional employment. The new hire must then pass a preplacement medical evaluation (described below). 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 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, fire officer, first responder, and hazardous materials operations. He had 35 years of fire fighting experience.

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)
- Urinalysis

Periodic medical evaluations are not required by the fire department. Annual medical evaluations are offered by the city's insurance carrier. Approximately half of the fire department members participate. The components of the medical 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. The results are not shared with the fire department contract physician. The city offers annual health fairs where vital signs can be taken and lab tests are offered. About half of the fire department members participate. Medical clearance to wear a respirator is not required. Return to work medical clearance is required for on-duty injuries. The member's primary care physician provides the initial clearance. The clearance is then approved by the city's human resource office and/or worker's compensation office. If a member misses two shifts due to illness, medical clearance for return to work is required from their primary care physician.

Wellness/Fitness Programs

The fire department has a mandatory wellness/fitness program, and exercise equipment is available in the fire stations. A candidate physical agility test is required for all fire fighter applicants (Appendix B). Annual physical agility tests are not required. The Captain participated in the fire department's mandatory wellness/fitness program by walking on the treadmill every shift.

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 are grouped into non-modifiable and modifiable. Non-modifiable risk factors include age older than 45, male gender, and family history of coronary artery disease. Modifiable risk factors include diabetes mellitus, smoking, high blood pressure, high blood cholesterol, and obesity/physical inactivity [AHA 2016a; NHLBI 2016]. The Captain had two non-modifiable risk factors (age over 45 and male gender) and three modifiable risk factors (smoking, high blood pressure, high blood cholesterol).

Coronary artery narrowing 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. 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. This sudden blockage is primarily due to blood clots (thromboses) that form on top of atherosclerotic plaques. Establishing a recent (acute) heart attack requires characteristic electrocardiographic changes, elevated cardiac enzymes, or a 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 electrocardiogram. Because the Captain did not have angina, it appears that a cardiac arrhythmia (discussed below) likely caused 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 2016b; Mayo Clinic 2016]. The Captain smoked and had CHD and left ventricular hypertrophy (LVH). These conditions increase the risk for a primary arrhythmia [AHA 2016b].

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Left Ventricular Hypertrophy
On autopsy, 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 had a history of hypertension.

Physiological Stress of Firefighting
Heart attacks and sudden cardiac death are also triggered by heavy physical exertion [Mittleman et al. 1993; Willich et al. 1993; Albert et al. 2000]. Among fire fighters, sudden cardiac events have been associated with/triggered by 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 walked on the treadmill for about 20 minutes. This activity expended about 4-5 metabolic equivalents, which is considered light-moderate 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 one condition addressed by NFPA 1582: Stage I hypertension.

Hypertension. The Captain had Stage I 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]. The Captain's hypertension was diagnosed in 2012 and was controlled with medication. The Captain's most recent blood pressure reading was normal.

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 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. 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.

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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 member's primary care physician provides medical clearance for return to work. Although the fire department contracts with a physician for medical evaluation of candidates, that physician is not involved in decisions regarding members. It is unclear if fire fighter's personal physicians were familiar with the recommendations of NFPA 1582 [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 2016], 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: Perform an annual physical ability evaluation.

Discussion: NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires the fire department to develop physical performance requirements for candidates and members who engage in emergency operations [NFPA 2013c]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2013c]. Once developed by the fire department, this evaluation could be performed as part of the annual training program.

Recommendation #6: Perform an autopsy on all on-duty fire fighter fatalities.

Discussion: In 2008, the USFA published the *Firefighter Autopsy Protocol* [USFA 2008]. The provisions of the protocol were to provide "a more thorough documentation of the causes of firefighter deaths for three purposes:

1. to advance the analysis of the causes of firefighter deaths to aid in the development of improved firefighter health and safety equipment, procedures, and standards;

2. to help determine eligibility for death benefits under the Federal government's Public Safety Officer Benefits Program, as well as state and local programs; and

3. to address an increasing interest in the study of deaths that could be related to occupational illnesses among firefighters, both active and retired."

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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 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.

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Appendix A
Visual Autopsy Findings

- Coronary artery atherosclerosis
- Hypertensive heart disease
  - Cardiomegaly (determined by chest x-ray)
  - Left Ventricular Hypertrophy (determined by chest x-ray)

Laboratory Tests
- Negative blood test for alcohol
- Positive blood test for cannabinoids (2.3 nanograms per milliliter) (normal is <0.019 micrograms per milliliter)

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Appendix B
Candidate Physical Agility Test

The physical agility test consist of the following components:

1. Climb 40-foot ladder on aerial
2. Climb 20-foot extension ladder
3. Begin candidate physical agility test – 6 minute time limit
   A. Candidate will begin on Stairmaster with a 75-pound weight vest for 3:20
   B. Candidate will pull 100-feet of hose hand-over-hand completely passed the desired line while having one knee in contact with the ground
   C. Candidate will carry 2 pieces of equipment 50-feet down to a cone and back to beginning location
   D. Candidate will then drag a 175-pound dead-weight dummy 50-feet across the finish line