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21

Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

A summary of a NIOSH fire fighter fatality investigation *March, 2014*

Volunteer Fire Captain Suffers Sudden Cardiac Death While Responding to a Call – New York

Executive Summary

On March 8, 2013, a 60-year-old volunteer Fire Captain failed to respond to the scene of an emergency call at 1054 hours. Several hours later (1530 hours) he was found laying in his driveway wearing a jacket with his fire department logo; his personal vehicle was running and the windshield was partially cleared of snow. Emergency medical service (EMS) personnel reported that the Captain was unresponsive with significant rigor mortis and no signs of life. Based on the local EMS protocols, the Captain was pronounced dead at the scene. Neighbors witnessed the Captain walking in his front yard less than a half hour before the call (1030 hours). Therefore, the Captain was assumed to be responding to the emergency call when he suffered a sudden cardiac event.

The autopsy report, completed by the County's Medical Examiner's office, listed the cause of death as "atherosclerotic and hypertensive cardiovascular disease." The autopsy revealed severe coronary atherosclerosis with a remote (old) myocardial infarction, cardiomegaly, and left ventricular hypertrophy. NIOSH offers the following recommendations to reduce the risk of heart attacks and sudden cardiac arrest among fire fighters at this and other fire departments across the country.

Ensure that all fire fighters receive an annual medical evaluation consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

Perform symptom-limiting exercise stress tests on fire fighters at increased risk for coronary heart disease (CHD) and sudden cardiac events.

Discontinue routine screening chest x-rays for members, unless clinically indicated.
Develop a mandatory comprehensive wellness and fitness program.

Perform a preplacement and an annual physical performance (physical ability) evaluation for all members.

Introduction & Methods

On March 8, 2013, a 60 year-old Fire Captain failed to respond to a fire call. Several hours later he was found dead in his driveway wearing his fire department jacket; his truck was running and the windshield was partially cleared of snow. NIOSH was notified of this fatality on March 12, 2013, by the U.S. Fire Administration. NIOSH contacted the affected fire department (FD) on March 12, 2013, and again on November 12, 2013, to obtain additional information and to schedule the investigation. On November 19, 2013, a contractor for the NIOSH Fire Fighter Fatality Investigation Team (the NIOSH investigator) conducted an on-site investigation of the incident.

Volunteer Fire Captain Suffers Sudden Cardiac Death While Responding to a Call – New York

Volunteer Fire Captain Suffers Sudden Cardiac Death While Responding to a Call – New York

Introduction & Methods (cont.)

During the investigation, the NIOSH investigator interviewed the following people:

- Chief of the FD
- Supervisor of the FD
- Lieutentant who worked with the Captain
- Wife of the deceased
- FD physician

The NIOSH investigator reviewed the following documents in preparing this report:

- FD incident report
- Ambulance pre-hospital care report
- Death certificate
- Medical examiner's report
- FD physician's medical records

Investigative Results

Incident. On the morning of March 8, 2013, the Captain helped his wife clear snow from their driveway using a snowblower from approximately 0515 to 0630 hours. The Captain and his wife returned to the inside of their home; he did not complain of unusual symptoms. His wife left for work at approximately 0720 hours. At approximately 1030 hours, a neighbor saw the Captain in his driveway in no apparent distress.

At 1054 hours the FD was dispatched to a motor vehicle crash scene. The Captain, who typically responded to all FD calls, did not respond to the scene. After the motor vehicle crash response, a FD Lieuteneant sent the Captain a cellphone text and the Captain did not respond.

At 1104 hours the FD responded to another alarm and, again, the Captain did not respond. Four hours later (at approximately 1530 hours) a neighbor saw the Captain laying in his driveway and called an ambulance. EMS personnel responded and found the Captain supine in his driveway, unconscious, unresponsive, and with evidence of rigor mortis. Based on local EMS protocols, the Captain was pronounced dead by EMS personnel on the scene.

When the EMS personnel found the Captain, his personal vehicle was running and the windshield was partially cleared of snow. The Captain had a broom in his hand. On the basis of these circumstances and the Captain's history of responding to all emergency calls, NIOSH investigators assume that the Captain was responding to the 1054 motor vehicle crash call when he suffered a sudden cardiac event.

Medical Findings. The death certificate and autopsy, both completed by the Deputy Medical Examiner, listed the cause of death as "atherosclerotic and hypertensive cardiovascular disease." Pertinent autopsy findings included severe coronary atherosclerosis with a remote (old) myocardial infarction of the posterior wall, cardiomegaly, and left ventricular hypertrophy. See Appendix A for more detailed autopsy information.

In 2009, the Captain was diagnosed with hypertension and type 2 diabetes mellitus during a FD medical evaluation. During that evaluation the Captain reported a negative exercise stress test within the past year, but specifics of that test were not available to NIOSH or the the FD physician. A resting electrocardiogram (ECG) was normal.

The Captain had his last FD medical evaluation in September 2011. During that visit his blood pres-

Volunteer Fire Captain Suffers Sudden Cardiac Death While Responding to a Call – New York

Investigative Results (cont.)

sure was 146/89 millimeters of mercury (mmHg). Laboratory tests revealed high blood glucose (207 milligrams per deciliter [mg/dL]; normal < 110 mg/dL), high triglycerides (347 mg/dL; normal < 150 mg/dL), and a desirable total cholesterol (173 mg/dL; desirable < 200 mg/dL) [National Cholesterol Education Program 2002]. Again, a resting ECG was normal and he was cleared for interior firefighting duties. The Captain was counseled about diet and exercise but no medications for hypertension or diabetes were prescribed.

In December 2011, the Captain had a follow-up visit with the FD physician. During this visit his blood pressure was still elevated (140/80 mmHg) as was his glucose (141 mg/dL) and hemoglobin A1C (7.1%; normal less than 7.0%).

The Captain had no known family history of premature cardiovascular death. He was a life-long smoker who smoked one to two packs of cigarettes per day. The Captain played golf but did not engage in regular vigorous exercise. At autopsy, the Captain was 73 inches tall and weighed about 270 pounds, giving him a body mass index of 35.6 kilograms per meter squared [CDC 2013].

Description of the Fire Department

The volunteer FD consists of 148 uniformed personnel serving a population of approximately 13,000 residents in a geographic area of approximately 3 square miles. The FD has three fire stations.

Membership and Training. Candidates must be 18 years of age unless they are part of the junior firefighting program (age 17 with parental permission). Candidates complete an application and are subject to a background check performed by the County Fire Marshall's office. Candidates are then interviewed by FD officers who make a recommendation to the Fire Chief. If the Fire Chief approves the candidate, the candidate is presented to the Board of Fire Commissioners which votes for provisional acceptance. If provisionally accepted, the candidate must pass a medical evaluation before becoming a member of the FD.

New members serve 1 year as probationary firefighters during which time they must attend the County Fire Service Academy and be certified in Primaries of Firefighting, Essentials of Firefighting, Vehicle Extrication, Mask Confidence and Hazardous Materials Awareness. A FD training committee provides the probationary firefighter with training on FD policies and procedures, work assignments, and firefighting skills.

Medical Evaluations/Medical Clearance. The FD requires a medical evaluation of candidates that includes the following components:

- A complete medical history and questionnaire
- Height, weight, and vital signs
- Physical examination
- Blood tests: complete blood count, chemistry panel which includes cholesterol and triglyceride measurements
- Urinalysis
- Urine drug test
- Spirometry (lung function tests)
- Resting ECG
- Chest x-ray
- Vision test
- Hearing test

Volunteer Fire Captain Suffers Sudden Cardiac Death While Responding to a Call – New York

Description of the FD (cont.)

These evaluations are performed by a contract physician to the FD, who makes a decision regarding medical clearance for firefighting duties.

The FD offers members an annual medical evaluation at no charge. However, the FD requires, at no charge, a periodic medical evaluation of all members based upon the following schedule:

- 18-35 years old - every 5 years;
- 36-45 years old - every 3 years;
- > 45 years old - every 2 years.

The components are the same as the candidate medical evalution except the urine drug test is omitted.

Fitness/Wellness Programs. The FD has a voluntary fitness program consisting of exercise equipment at the fire station(s) with the ability to work with a personal fitness trainer. In addition, annual respiratory fit testing is conducted by the FD. No candidate or member physical ability testing is conducted.

Discussion

The Pathophysiology of Sudden Cardiac Death. Sudden cardiac death is most often caused by myocardial infarction due to coronary heart disease or a fatal arrhythmia (disruption in the electrical signal of the heart).

Coronary Heart Disease. The most common risk factor for cardiac arrest and sudden cardiac death is CHD, defined as the build-up of atherosclerotic plaque in the coronary arteries [AHA 2012]. Risk factors for CHD include three non-modifiable factors (age older than 45, male gender, and family history of CHD) and six modifiable factors (smoking, hypertension, high blood cholesterol, obesity, physical inactivity, and diabetes mellitus) [AHA 2012; National Cholesterol Education Program 2002]. The Captain had seven of these risk factors (age over 45, male, smoking, hypertension, obesity, physical inactivity, and diabetes mellitus).

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]. Most heart attacks occur when a vulnerable plaque ruptures, causing a blood clot to form and occlude a coronary artery. Establishing a recent (acute) heart attack requires one or more of the following: characteristic ECG changes, elevated cardiac enzymes, or coronary artery thrombus. In this case, the Captain did not have a heart rhythm to conduct an ECG, he died before cardiac enzymes would become elevated, and no thrombus was identified at autopsy. However, heart attacks can occur without evidence of a coronary thrombus [Davies 1992; Farb et al. 1995] and evidence of an earlier heart attack was discovered at autopsy. Therefore, it is possible the Captain suffered a heart attack which caused his sudden cardiac death.

Cardiomegaly/Left Ventricular Hypertrophy. The autopsy revealed that the Captain had cardiomegaly (650 g) and left ventricular hypertrophy (1.6 cm). Hypertrophy of the left ventricle is relatively common among individuals with long-term 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 and probably had ischemia due to his underlying CHD. Both cardiomegaly and left ventricular hypertrophy independently increase the risk

Volunteer Fire Captain Suffers Sudden Cardiac Death While Responding to a Call – New York

Discussion (cont.)

for a primary cardiac arrhythmia and sudden cardiac death [Levy et al. 1990]. Therefore, it is also possible that the Captain suffered a primary cardiac arrhythmia that led to his sudden cardiac death.

Firefighting and Sudden Cardiac Death. Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers sudden cardiac death [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]. It is unclear if the activity of clearing snow off his driveway using a snowblower or off his windshield using a broom would be considered heavy exertion. However, some authors have suggested that activation of the sympathetic nervous system (adrenaline surge) associated with alarm response and emergency operations may trigger a cardiac event in fire fighters (Soteriades 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 (NFPA) developed NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments [NFPA 2013]. This voluntary industry standard provides (1) the components of a preplacement and annual medical evaluation and (2) medical fitness for duty criteria. The Captain had several medical conditions warranting medical fitness for duty concerns including diabetes mellitus and a several risk factors for CHD.

Diabetes Mellitus. NFPA 1582 provides guidance for fire department physicians when treating fire fighters with diabetes [NFPA 2013]. The standard states that fire fighters with diabetes mellitus that is controlled by diet, exercise, or oral hypoglycemic agents should be restricted from duty unless the member meets all of the following criteria:

- has had hemoglobin A1C measured at least 4 times a year over the last 12 months prior to evaluation if the diagnosis of diabetes has been present over 1 year.
- if on oral hypoglycemic agents, has had no episodes of severe hypoglycemia (defined as requiring assistance of another in the preceding year)
- has achieved a stable blood glucose as evidenced by hemoglobin A1C level less than 8% during the prior 3-month period
- has a dilated retinal exam by a qualified ophthalmologist or optometrist that shows no higher grade of diabetic retinopathy than microaneurysms
- has normal renal function on the basis of a calculated creatinine clearance greater than 60 milliliters per minute and absence of proteinuria
- has no autonomic or peripheral neuropathy
- has normal cardiac function without evidence of myocardial ischemia on cardiac stress testing (to at least 12 METs) by ECG and cardiac imaging.

The Captain had only mildly high hemoglobin A1C. However, based on the current recommendations an exercise stress would have been warranted.

Risk Factors for Coronary Heart Disease. The Captain had multiple risk factors for CHD, and at autopsy, was found to have severe CHD and a previous heart attack. Exercise stress tests can be used to identify occult CHD. Recommendations for conducting exercise stress tests on asymptomatic individuals without known heart disease are

Volunteer Fire Captain Suffers Sudden Cardiac Death While Responding to a Call – New York

Discussion (cont.)

varied. The following paragraphs summarize the positions of widely recognized organizations on this topic.

NFPA 1582, a voluntary industry standard, recommends an exercise stress test with or without imaging be performed "when clinically indicated by history or symptoms" and refers the reader to its Appendix A [NFPA 2013]. Items in Appendix A are not standard requirements, but are provided for "informational purposes only." Appendix A recommends using submaximal (85% of predicted maximal heart rate) stress tests as a screening tool to evaluate a fire fighter's aerobic capacity. Cardiology evaluation with a symptom-limiting stress test and imaging studies should be used for fire fighters with the following conditions:

- abnormal screening submaximal tests
- cardiac symptoms
- known coronary artery disease (CAD)
- one or more risk factors* for CAD (in men older than 45 and women older than 55)
- fire fighters with a Framingham Risk Score > 10% [NHLBI 2013]

Risk factors are defined as hypercholesterolemia (total cholesterol greater than 240 milligrams per deciliter), hypertension (diastolic blood pressure greater than 90 mmHg), smoking, diabetes mellitus, or family history of premature CAD (heart attack or sudden cardiac death in a first-degree relative less than 60 years old).

The American College of Cardiology/American Heart Association (ACC/AHA) has also published exercise testing guidelines [Gibbons et al. 2002]. The ACC/AHA guideline states the evidence is "less well established" (Class IIb) for the following groups:

- persons with multiple risk factors (defined similarly to those listed by the NFPA)
- asymptomatic men older than 45 years and women older than 55 years:
  - who are sedentary and plan to start vigorous exercise
  - who are involved in occupations in which impairment might jeopardize public safety (e.g., fire fighters)
  - who are at high risk for CAD due to other diseases (e.g., peripheral vascular disease and chronic renal failure)

The U.S. Department of Transportation provides guidance for those seeking medical certification for a commercial driver's license. An expert medical panel recommended exercise tolerance tests (stress tests) for asymptomatic "high risk" drivers [Blumenthal et al. 2007]. The panel defines high risk drivers as those with any of the following:

- diabetes mellitus
- peripheral vascular disease
- age 45 and above with multiple risk factors for coronary heart disease
- Framingham risk score predicting a 20% coronary heart disease event risk over the next 10 years

The U.S. Preventive Services Task Force (USPSTF) does not recommend stress tests for asymptomatic individuals at low risk for CHD events. For individuals at increased risk for CHD events, the USPSTF found "insufficient evidence to recommend for or against routine screening with ECG, exercise tolerance test, or electron beam computerized tomography scanning …" Rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes) [USPSTF 2004].

Volunteer Fire Captain Suffers Sudden Cardiac Death While Responding to a Call – New York

Discussion (cont.)

The USPSTF does note that "For people in certain occupations, such as pilots, and heavy equipment operators (for whom sudden incapacitation or sudden death may endanger the safety of others), consideration other than the health benefit to the individual patient may influence the decision to screen for coronary heart disease."

In summary, available guidelines indicate that an exercise stress test was appropriate given the Captain's age and his CHD risk factors. Specifically, NFPA 1582 recommends that a stress test be performed for individuals with diabetes mellitus or the metabolic syndrome (a group of metabolic factors associated with insulin resistance and increased risk of cardiovascular disease) because of the greater risk of cardiovascular disease in individuals with these conditions. A stress test would also have been recommended based on the AHA/ACC and DOT guidelines discussed above. Had a stress test been performed, perhaps his underlying CHD could have been identified and treated.

Recommendations

NIOSH investigators offer the following recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters.

Recommendation #1: Ensure that all fire fighters receive an annual medical evaluation consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

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 [NFPA 2013; IAFF, IAFC 2008]. 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. To ensure improved health and safety of candidates and members, and to ensure continuity of medical evaluations, it is recommended the FD comply with this recommendation, particularly the section addressing CHD issues. However, the FD is not legally required to follow the NFPA standard or the IAFF/IAFC initiative. Applying this recommendation involves economic repercussions and may be particularly difficult for smaller fire departments to implement.

Recommendation #2: Perform symptom-limiting exercise stress tests on firefighterss at increased risk for CHD and sudden cardiac events.

Firefighters with multiple or severe CHD risk factors or a high Framingham score are at increased risk of a sudden cardiac event [NHLBI 2013]. The Captain had multiple CHD risk factors (male, age over 45 years, obesity, hypertension, smoking, physical inactivity, and type 2 diabetes mellitus), therefore, an exercise stress test was warranted.

Recommendation #3: Discontinue routine screening chest x-rays for members, unless clinically indicated.

Annual chest x-rays are conducted as part of the FD's annual medical assessment. According to NFPA 1582, "chest x-rays shall include an initial baseline and shall be repeated every 5 years or as

Recommendations (cont.)

medically indicated" [NFPA 20013]. Doing chest x-rays every year, or even every 5 years, exposes members to unnecessary radiation and represents an unnecessary expense for the FD. Routine screening chest x-rays are not recommended by the OSHA Hazmat Standard, unless clinically indicated (e.g., respiratory symptoms) [NIOSH 1985; CFR 2012].

Recommendation #4: Develop a mandatory comprehensive wellness and fitness program to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Guidance for fire department wellness/fitness programs to reduce risk factors for cardiovascular disease and improve cardiovascular capacity is found in NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, the National Volunteer Fire Council Health and Wellness Guide, and in Firefighter Fitness: A Health and Wellness Guide [USFA 2004; IAFF, IAFC 2008; NFPA 2008; Schneider 2010]. Worksite health promotion programs have been shown to be cost effective by increasing productivity, reducing absenteeism, and reducing the number of work-related injuries and lost work days [Stein et al. 2000; Aldana 2001]. Fire service health promotion programs have been shown to reduce CHD risk factors and improve fitness levels, with mandatory programs showing the most benefit [Dempsey et al. 2002; Womack et al. 2005; Blevins et al. 2006]. A study conducted by the Oregon Health and Science University reported a savings of more than $1 million for each of four large fire departments implementing the IAFF/IAFC wellness/fitness program compared to four large fire departments not implementing a program. These savings were primarily due to a reduction of occupational injury/illness claims with additional savings expected from reduced future nonoccupational healthcare costs [Kuehl et al. 2007, 2013]. The FD has exercise equipment in all its fire stations and has hired fitness trainers to work with firefighters on individual fitness programs. However, NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program.

Recommendation #5: Perform a preplacement and an annual physical performance (physical ability) evaluation for all members.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires the FD to develop physical performance requirements for candidates and members who engage in emergency operations [NFPA 2013b]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2013b]. This could be incorporated into the annual task-level training program.

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Volunteer Fire Captain Suffers Sudden Cardiac Death While Responding to a Call – New York

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio. Denise L. Smith, Ph.D, led the investigation and coauthored the report. Dr. Smith is professor of Health and Exercise Sciences, and Director of the First Responder Health and Safety Laboratory at Skidmore College. She is a member of the NFPA Technical Committee on Occupational Safety and Health. Dr. Smith was working as a contractor with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component during this investigation. Thomas Hales, MD, MPH, provided medical consultation and coauthored 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).

Appendix A

Autopsy Findings

- Heart size and structure
  - Heart weight = 650 grams (expected weight 432 grams) [Silver and Silver 2001]
  - Left ventricular hypertrophy
    - Left ventricular wall = 1.6 centimeters (cm)
    - Right ventricular wall = 0.4 cm
  - Area of (3 x 2, 1.2 cm) of fibrosis and focal thinning of left ventricular thickness down to 0.9 cm consistent with a remote (old) myocardial infarction of the posterior wall.
- Coronary arteries
  - Coronary artery normally distributed for a right dominate circulation
  - Markedly and diffusely calciefied and severely stenosed coronary arteries
  - No coronary thrombosis
- Micrposcopic examination
  - Extensive myocardial fibrous scarring consistent with remote myocardial infarction
  - Hypertrophy of myofibers
  - Coronary arteries with severe calcific atherosclerotic changes and evidence of recanalization
- No drugs of abuse detected

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