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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 *April, 2014*

Volunteer Lieutenant Suffers Sudden Cardiac Death at Fire Station While Doing Fitness Training – New York

Executive Summary

On November 11, 2013, a 52-year-old volunteer Lieutenant (LT) attended the monthly business meeting at the fire department (FD). Following the meeting he went upstairs to use the exercise room. After approximately 5 minutes, members heard a crashing sound, found the LT unresponsive and began cardiopulmonary resuscitation (CPR). The ambulance crew that was stationed at that FD began advanced cardiac life support (ACLS). The LT was transported to the emergency department (ED) where ACLS continued. Despite these efforts, the LT died. The death certificate and autopsy report, both completed by the County's Chief Medical Examiner, listed the cause of death as "atherosclerotic and hypertensive cardiovascular disease." The autopsy revealed severe coronary atherosclerosis but no evidence of an acute thrombus or plaque hemorrhage.

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.

Ensure fire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

Perform an annual physical performance (physical ability) evaluation.

Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

Introduction & Methods

On November 11, 2013, a 52-year-old volunteer LT suffered a sudden cardiac event while exercising at his fire station. NIOSH was notified of this fatality on November 13, 2013, by the U.S. Fire Administration. NIOSH contacted the affected FD on November 14, and again on November 27, 2013, to obtain additional information and to schedule the investigation. On December 11, 2013, a contractor for the NIOSH Fire Fighter Fatality Investigation Team (the NIOSH investigator) conducted an on-site investigation of the incident.

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

- Chief of the FD
- Assistant Chief (serving as Chief at the time of the incident) who provided initial care
- EMS personnel who provided treatment
- Primary care physician

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

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

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Investigative Results

Incident. On November 11, 2013, at 1900 hours, the FD held its monthly business meeting at the fire station. The LT arrived at the fire station before the meeting to work out in the station's upstairs exercise room. The LT used the exercise room on a regular basis, 4 to 6 times a week for aerobic and weight training sessions lasting from 30 to 60 minutes. Based on the log book, the LT was in the exercise room for 30 minutes (1815 and 1845 hours) but the extent and type of exercise he did were unknown). The business meeting ended at approximately 2100 hours and the LT returned to the exercise room to complete his workout.

Approximately 5 minutes after the LT went upstairs (2115 hours) members heard a loud crash. The Chief of the FD, a fire fighter (FF), and an emergency medical technician (EMT) stationed in the fire station rushed upstairs and found the LT pulseless and unresponsive. The Chief and the FF began CPR while the EMT alerted her partner (a paramedic) and retrieved the automatic external defibrillator (AED) and other equipment from the ambulance stationed in the bay beneath the exercise room.

The AED indicated that a shock was advised; it was delivered with no change in the LT's status. An oropharyngeal airway was inserted and the LT was provided with oxygen via a bag-valve mask. An intravenous line was placed and cardiac drugs were administered per ACLS protocols. The LT was secured to a backboard and carried down a flight of stairs to the ambulance. In the back of the ambulance the LT was defibrillated a second time with no change in his clinical status.

At 2136 hours the ambulance left the station en route to the hospital's ED with CPR and ACLS in progress. At 2136 hours a cardiac monitor replaced the AED and revealed pulseless electrical activity. At approximately 2139 hours, an endotracheal tube replaced the oropharyngeal airway, with proper placement ensured by breath sounds in both lung fields, an esophageal detection devise, and capnography [Neumar et al. 2010]. At 2144 hours, the ambulance arrived at the ED.

Upon arrival at the ED, the placement of the endotracheal tube was confirmed with capnography. Another IV line was established, cardiac medications were administered, and defibrillation was attempted. The LT did not regain a viable heart rhythm during the resuscitation efforts and a cardiac ultrasound revealed no cardiac wall motion. At 2223 hours, approximately 1 hour and 10 minutes after his collapse, the LT was pronounced dead and resuscitation efforts were discontinued.

Medical Findings. The death certificate and autopsy, both completed by the Chief Medical Examiner, listed the cause of death as "atherosclerotic and hypertensive cardiovascular disease." Pertinent autopsy findings included severe atherosclerosis with 99% calcified luminal stenosis of the right coronary artery and 90% calcified luminal stenosis of the left anterior descending and left marginal artery. No coronary thrombosis or plaque hemorrhage was noted. See Appendix A for more detailed autopsy information.

The LT had long-standing hypertension, diagnosed in 1999 and managed with antihypertensive medications by his primary care physician. His blood pressure was well-controlled at his most recent measurement in August 2013 (132/90

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Investigative Results (cont.)

millimeters of mercury [mmHg]). The LT was a nonsmoker and a regular exerciser. He was cleared for unrestricted fire fighting duty during his last FD medical evaluation in April 2011. At autopsy, the LT was 70 inches tall and weighed about 187 pounds, giving him a body mass index of 26.8 kilograms per meter squared [CDC 2011].

Description of the Fire Department

The volunteer FD consists of 22 uniformed personnel serving a population of approximately 800 residents in a geographic area of one square mile.

Membership/Training. Candidates must have a valid driver's license and be 18 years of age. After passing a background check, candidates are voted on by the membership and become probationary FD members for 90 days. During the probationary period, provisional members receive weekly training by paid consultants. Additionally, FD officers train the provisional members for a minimum of 2 hours per month. Once the training is complete, a "badge test" is administered to ensure that new members are proficient in firefighting skills. Once the badge test is passed, the FD Chief makes the final determination regarding membership.

Medical Evaluations/Medical Clearance. The FD requires pre-placement and periodic medical evaluations. These evaluations may be done by a member's primary care provider (PCP) or they can be conducted by the medical group under contract with the FD. If the evaluation is conducted by the member's PCP, then the components of the evaluation are determined by the PCP who then signs a note to the FD regarding the member's clearance for fire fighting duties. If the medical evaluation is conducted by the contract medical group, the FD requires a medical history, physical evaluation, urine dip test for glucose and ketones, and a hearing test.

Following an injury or illness, the member must present the FD with a PCP's note regarding return to work.

Fitness/Wellness Programs. The FD has exercise equipment at the fire station but does not provide a fitness or wellness program.

Discussion

Atherosclerotic Coronary Heart Disease. The most common risk factor for cardiac arrest and sudden cardiac death is coronary heart disease (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 LT had four of these risk factors; he was a male over the age of 45 with a family history of CHD and diagnosed hypertension.

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

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Discussion (cont.)

(acute) heart attack requires one or more of the following: characteristic electrocardiogram (EKG) changes, elevated cardiac enzymes, or coronary artery thrombus. In this case, the LT did not have a heart rhythm to conduct an EKG tracing, 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].

Primary Arrhythmia. Lethal ventricular arrhythmias can cause sudden cardiac deaths [Kelesidis and Travin 2012]. Risk factors for arrhythmias include cardiac disease, heart attack, sleep apnea, dietary supplements, smoking, alcohol, drug abuse, medications, diabetes, and hyperthyroidism [AHA 2012; Mayo Clinic 2013]. The LT's autopsy revealed severe coronary artery disease which increases the risk for primary arrhythmia [AHA 2012; Mayo Clinic 2013].

Strenuous Exertion and Sudden Cardiac Death. Epidemiologic studies in the general population have found that heavy physical exertion can trigger a heart attack and/or sudden cardiac death [Tofler et al. 1992; Mittleman et al. 1993; Willich et al. 1993; Albert et al. 2000]. Epidemiologic studies among fire fighters have shown that fire suppression, training, alarm response, or strenuous physical activity on the job, in the preceding 12 hours, increases the risk for a sudden cardiac event [Kales et al. 2003; Hales et al. 2007; Kales et al. 2007].

NIOSH investigators conclude the LT's sudden cardiac death was due to a primary arrhythmia or a myocardial infarction associated with his underlying undiagnosed heart disease. Either condition could have been triggered by the physical exertion of exercising in the fire station.

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.

NFPA 1582 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

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Discussion (cont.)

deciliter), hypertension (diastolic blood pressure greater than 90 mm of mercury), 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 EKG, 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]. 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."

The LT had several risk factors for CHD (age, male gender, family history, hypertension) and at autopsy was found to have severe atherosclerosis. Available guidelines indicate that an exercise stress test was appropriate given the LT's age (>45 years) and his other CHD risk factors. 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.

Recommendations (cont.)

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 (WFI) [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. While the FD is following many of the components of NFPA 1582, it is not conducting stress tests for fire fighters at increased risk of coronary heart disease. Applying this recommendation involves economic repercussions and may be particularly difficult for smaller fire departments to implement. The FD is not legally required to follow the NFPA standard or the WFI guideline.

To overcome the financial obstacle of medical evaluations, the FD could urge current members to get annual medical clearances from their private physicians. Another option is having the annual medical evaluations completed by paramedics and emergency medical technicians from the local ambulance service (vital signs, height, weight, visual acuity, and electrocardiogram). This information could then be provided to a community physician, perhaps volunteering his or her time, who could review the data and provide medical clearance or further evaluation, if needed. The more extensive portions of the medical evaluations could be performed by a private physician through the fire fighter's personal insurance, provided by a physician volunteer, or paid for by the FD, city, or state. Sharing the financial responsibility for these evaluations between fire fighters, the FD, the city, the state, and physician volunteers may reduce the negative financial impact on recruiting and retaining needed fire fighters.

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

According to NFPA 1582 and the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, the FD should have an officially designated physician who is responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty [NFPA 2013; IAFF/IAFC 2008]. The physician should review job descriptions and essential job tasks required for all FD positions to understand the physiological and psychological demands of firefighting and the environmental conditions under which fire fighters perform, as well as the personal protective equipment they must wear during various types of emergency operations. In addition, this physician should oversee all fitness for duty recommendations provided by PCP and have the final authority for all medical fitness for duty decisions. To ensure the FD physician or other PCP is familiar with NFPA 1582, the NIOSH investigators recommend the FD provide a copy or a link to the NFPA website where a copy could be purchased or viewed on-line at no charge.

Recommendation #3: Perform an annual physical performance (physical ability) evaluation.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program

Recommendations (cont.)

recommends that the FD annually evaluate and certify FD members who engage in emergency operations as having met the physical performance requirements identified in Paragraph 10.2.3 of the standard [NFPA 2007]. This is recommended to ensure that fire fighters are physically capable of performing the essential job tasks of structural fire fighting. The physical ability test could be performed as part of the FD's training program. Recommendation #4: Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

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 non-occupational healthcare costs [Kuehl 2007; Kuehl 2013]. The FD does not have a wellness/fitness program. Given the FD's structure, the National Volunteer Fire Council program would be very helpful [USFA 2004]. NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program.

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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 = 410 grams (expected weight 360 grams) [Silver and Silver 2001]
  - Mild-moderate dilation of both the right and left ventricular chambers
  - Heart valves are in usual anatomic positions and are without gross abnormalities with the exception of the mitral valve, which shows mild myxomatous degeneration but no interchordal hooding
- Coronary arteries
  - Coronary arteries show normal corse and caliber and the right-sided circulation is dominant
  - High-grade calcified atherosclerotic lesions involving major coronary arteries
  - 99% luminal stenosis of the mid right coronary artery
  - 90% luminal stenosis of the left anterior descending artery
  - 90% luminal stenosis of the left marginal branch
  - No coronary thrombosis ot plaque hemorrhage identifed

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