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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 *December, 2012*

Fire Fighter Suffers Sudden Cardiac Death During Ladder Training – Texas

Executive Summary

On May 17, 2012, a 69-year-old male volunteer fire fighter ("the FF") was participating in ladder training as part of the state 70-hour, 11-component fire fighter introduction training program. The FF had completed 10 of the training components, with only the ladder training remaining. The ladder training involved climbing a 24-foot extension ladder to the second story window of the training building while wearing full turnout gear and a self-contained breathing apparatus (SCBA) (off-air), and carrying an ax. After entering the second floor window, the FF was supposed to descend an attic ladder to the first floor and exit the structure. After climbing most of the distance up the extension ladder, the FF became dizzy and climbed back down to the ground. Suddenly he became unresponsive and pulseless; crew members began cardiopulmonary resuscitation (CPR) and requested an ambulance (2050 hours). The on-site paramedic unit and an ambulance unit provided advanced life support (ALS) on-scene and en route to the local hospital's emergency department (ED). En route and in the ED, a total of three shocks (defibrillations) were administered without return of a heart rhythm or pulse. After 11 minutes of resuscitation inside the ED, the FF was declared dead at 2133 hours, and resuscitation efforts were discontinued.

The death certificate listed "acute myocardial infarction" as the cause of death. No autopsy was performed. Given the FF's probable underlying coronary heart disease (CHD), NIOSH investigators concluded that the physical stress of ladder training triggered a heart attack or an arrhythmia, which resulted in his sudden cardiac death.

NIOSH investigators offer the following recommendations to prevent future similar incidents and to address general safety and health issues.

Provide preplacement and annual medical evaluations to all fire fighters in accordance with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

Ensure that fire fighters are cleared for 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.

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

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

Perform an autopsy on all on-duty fire fighter fatalities.

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Introduction & Methods

On May 17, 2012, a 69-year-old male volunteer FF suffered sudden cardiac death while participating in ladder training. NIOSH contacted the affected fire department (FD) on May 22, 2012, to gather additional information, and on June 19, 2012, to initiate the investigation. On July 9, 2012, a safety and occupational health specialist and a visiting scientist 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
- Training academy training coordinator
- Deputy state fire marshal
- FF's family

NIOSH personnel reviewed the following documents:

- FD standard operating procedures
- FD annual report for 2011
- FD incident report
- Police report
- Witness statements
- Emergency medical service (ambulance) report
- Hospital ED records
- Death certificate

Investigative Results

Incident. On May 17, 2012, the FD conducted ladder training at the nearby state fire academy. For this FF, the ladder training was the only remaining component of the 11-component, 70-hour state fire fighter introduction training program. Fire fighters arrived at about 1900 hours, and the training began. Weather conditions included a temperature of 83 degrees Fahrenheit (°F) and relative humidity of 48%, giving a heat index of 84°F [NOAA 2012].

Investigative Results (cont.)

The first portion of the ladder training involved about 75 minutes of classroom work. The class then relocated outside to the ladder props for the hands-on portion. The ladder training included climbing a 24-foot extension ladder to the second story window of the training building while wearing full turnout gear and SCBA (off-air) and carrying an ax. The FF then was to enter the second floor window and descend an attic ladder through a hole in the second-story floor to the first floor. After the FF climbed most of the distance up the extension ladder to the second floor window, he reported feeling dizzy, and the trainers noted slurred speech. The FF then descended the extension ladder to the ground where crew members assisted him. Suddenly the FF became unresponsive and pulseless. Crew members began CPR and requested an ambulance at 2050 hours. The on-site paramedic unit responded and transported the FF to the training facility's first aid station where advanced life support treatment (cardiac monitoring) began.

The ambulance arrived on-scene at 2101 hours just as the FF and the field paramedic unit arrived at the first aid station. ALS continued, including cardiac monitoring, intravenous line placement, cardiac resuscitation medications, and intubation. Intubation tube placement was verified by carbon dioxide measurement. The ambulance left the training facility's first aid station at 2110 hours. En route cardiac monitoring revealed ventricular fibrillation, and one shock was administered. After arrival at the hospital at 2119 hours and inside the ED, two additional shocks were administered with no change in his clinical status. The original intubation tube was removed, and the FF was re-intubated as the first tube had ceased operating properly. After 14 minutes of treatment inside the

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Investigative Results (cont.)

ED, the FF was pronounced dead, and resuscitation efforts were discontinued (2133 hours).

Medical Findings. The death certificate listed "acute myocardial infarction" as the cause of death. No autopsy was performed.

The FF was 74 inches tall and weighed 200 pounds, giving him a near normal body mass index of 25.7 kilograms per meters squared [CDC 2011]. According to medical records, the FF's risk factors for CHD included type II diabetes mellitus (diagnosed in 2006), hypertension, and hyperlipidemia. He was prescribed a hyperglycemia-regulating medication, two blood pressure-lowering medications, and a cholesterol-lowering medication, which controlled these conditions. The FF never complained of cardiac symptoms.

Description of the Fire Department

At the time of the NIOSH investigation, the FD consisted of three fire stations with 38 volunteer uniformed personnel. The FD served 6,200 residents in a geographic area of 140 square miles. In 2011, the FD responded to 515 incidents: 239 fire calls and 276 emergency medical calls.

Membership and Training. The FD requires new fire fighter applicants to be 18 years of age, have a valid state driver's license, pass an interview, and pass a background check prior to being accepted as a member. The new member completes a medical statement and, if there are no significant medical conditions identified, the member begins training. Specific training programs are based on the position (structural fire fighter, driver operator, maintenance, etc.). The overall training program is based on the State Firemen's and Fire Marshal's Association tiered program similar to NFPA 1001, *Standard for Fire Fighter Professional Qualifications* [NFPA 2013]. To respond to emergencies and operate on the exterior only, a new member must complete Module 1, a 70-hour, 11-component program. To become an interior structural Fire Fighter I, the member must complete Modules 2 and 3. The FF had 7 months of fire fighting experience and had completed Module I: Fire Fighter I Introduction.

Description of the FD (cont.)

Preplacement and Periodic Medical Evaluations. The FD does not require preplacement medical evaluations. Periodic (annual) medical evaluations are required for members who are suppression fire fighters. Medical clearance to wear a respirator is required for suppression fire fighters. Members injured on duty or who become ill and miss FD responses, training, or meetings must be evaluated by the member's primary care physician who forwards his or her determination for return-to-duty to the FD.

Health and Wellness Programs. The FD does not have a wellness/fitness program, but exercise equipment is available in the fire stations. No annual physical ability test is required. The FF did not participate in a fitness/wellness program.

Discussion

Atherosclerotic Coronary Heart Disease. 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 (CAD), smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes [NHLBI 2011; AHA 2012a]. The FF had three modifiable CHD risk factors (high blood pressure, high blood cholesterol, and diabetes).

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 FF's cardiac enzymes were not tested, the EKG did not reveal characteristic changes of a heart attack, and no autopsy was performed to identify a thrombus. Therefore, although the FF's sudden cardiac death was consistent with a heart attack, the NIOSH investigator could not definitively confirm the diagnosis of a heart attack.

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]. Heart attacks 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 FF had climbed a 24-foot extension ladder most of the distance to the second floor window while wearing full turnout gear and SCBA. This activity expended about 8 metabolic equivalents (METs), which is considered moderate physical activity [Gledhill and Jamnik 1992; Ainsworth et al. 2011].

Primary Arrhythmia. In addition to a heart attack, a primary cardiac arrhythmia (e.g., ventricular tachycardia/fibrillation) could have been responsible for the FF's sudden cardiac death. Risk factors for arrhythmias include heart disease, heart attack, dietary supplements, smoking, alcohol, drug abuse, medications, diabetes, and hyperthyroidism [Mayo Clinic 2011; AHA 2012b]. With the exception of diabetes, the FF was not known to have any of these conditions. Therefore, a heart attack was most likely the cause of his sudden cardiac death.

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the NFPA developed NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments* [NFPA 2007a]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. The FF had one condition, diabetes mellitus, relevant to medical clearance.

Discussion (cont.)

Diabetes Mellitus. NFPA 1582 provides guidance for fire department physicians to follow when treating diabetic fire fighters. 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:

1) If on oral hypoglycemic agents, has had no episodes of severe hypoglycemia (defined as requiring assistance of another in the preceding year)
2) Has achieved a stable blood glucose as evidenced by HA1C level less than 8 during the prior 3-month period
3) Has a dilated retinal exam by a qualified ophthalmologist or optometrist that shows no higher grade of diabetic retinopathy than microaneurysms
4) Has normal renal function on the basis of a calculated creatinine clearance greater than 60 milliliters per minute and absence of proteinuria
5) Has no autonomic or peripheral neuropathy
6) Has normal cardiac function without evidence of myocardial ischemia on cardiac stress testing (to at least 12 METs) by EKG and cardiac imaging [NFPA 2007a].

The FF was prescribed an oral diabetic medication and was asymptomatic. According to NFPA 1582, he needed an eye exam and a stress test (as outlined in #3 and #6 above) to participate in all fire fighter duties [NFPA 2007a]. However, because the FF's duties were confined to exterior fire suppression, support, and driver/operator, it is unclear if these additional medical tests were required for his medical clearance.

Coronary Heart Disease and Exercise Stress Tests. The FF had multiple risk factors for coronary heart disease and despite being asymptomatic, should have had an exercise stress test to screen for coronary heart disease. Recommendations for conducting exercise stress tests on asymptomatic individuals without known heart disease are varied. The following paragraphs summarize the positions of widely recognized organizations on this topic.

National Fire Protection Association (NFPA) 1582, a voluntary industry standard, recommends an exercise stress test performed "as clinically indicated by history or symptoms" and refers the reader to Appendix A [NFPA 2007a]. Items in Appendix A are not standard requirements, but are provided for "informational purposes only." Appendix A recommends using submaximal (85% of predicted heart rate) stress tests as a screening tool to evaluate a fire fighter's aerobic capacity. Maximal (i.e., symptom-limiting) stress tests with imaging should be used for fire fighters with the following conditions:

- abnormal screening submaximal tests
- cardiac symptoms
- known CAD
- two or more risk factors for CAD (in men older than 45 and women older than 55)

Risk factors are defined as hypercholesterolemia (total cholesterol greater than 240 milligrams per 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).

Discussion (cont.)

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 that the evidence to conduct stress tests in asymptomatic individuals with diabetes mellitus is "Class IIa," which is defined as "conflicting evidence and/or a divergence of opinion about the usefulness/efficacy but the weight of the evidence/opinion is in favor." 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 coronary heart disease events. For individuals at increased risk for coronary heart disease 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."

Given the FF's age and CHD risk profile, the NFPA, the ACC/AHA, and the Department of Transportation would have recommended a symptom limiting exercise stress test.

Recommendations

NIOSH investigators offer the following recommendations to prevent similar incidents in the future and to address general safety and health issues.

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.

Guidance regarding the content and frequency of these medical evaluations can be found in NFPA

Recommendations (cont.)

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 2007a; 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 stress tests to screen for 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 IAFF/IAFC 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 EKG). 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 at the fire fighter's expense (personal or through 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 that fire fighters are cleared for 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.

Guidance regarding medical evaluations and examinations for structural fire fighters can be found in NFPA 1582 and in the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative [NFPA 2007a; IAFF, IAFC 2008]. According to these guidelines, 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. The physician should review job descriptions and essential job tasks required for all FD positions and ranks 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.

Recommendation #3: 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 (NVFC) 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

Recommendations (cont.)

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 CAD 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 2007].

The FD currently does not offer a voluntary wellness/fitness program. However, exercise equipment is available in the fire stations. Given the FD's structure, the NVFC program would be applicable [USFA 2004]. NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program.

Recommendation #4: Perform 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 2007b]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2007b]. This could be incorporated into the annual task-level training program.

Recommendation #5: Perform an autopsy on all on-duty fire fighter fatalities.

In 2008, the USFA published the Firefighter Autopsy Protocol [USFA 2008]. With this publication, the USFA hoped 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 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. Mr. Darius Hixon, a visiting scientist from Stillman College in Tuscaloosa, Alabama, accompanied Mr. Baldwin on the investigation. 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 Heath, and Vice-Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).