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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 *August, 2014*

Firefighter Suffers Fatal Heart Attack at Fire Station After Returning from a Fire Alarm – New York

Executive Summary

On April 5, 2013, at 0800 hours, a 57-year-old male career firefighter (FF) began his 24-hour shift. As the Acting Lieutenant for his company, the FF and his crew responded to two emergency medical calls during the day and early evening. The FF spent much of the evening in the officer's bunk room but had ice cream with a crew member before retiring for the evening at approximately 2100 hours. At 0021 hours, on April 6, the FF and his crew responded to an automatic fire alarm at a local college fraternity house. While investigating the cause of the automatic alarm activation, the FF climbed five flights of stairs in full personal protective equipment (PPE), including his self-contained breathing apparatus (SCBA). When the crew returned to the station at approximately 0045 hours, the FF complained of indigestion. The FF was last seen alive at approximately 0100 hours when he retired to his bunk room. At 0656 hours the crew was dispatched to a medical alarm, but the FF did not respond. When the crew returned to the fire house at 0715 hours, the FF was found unresponsive in his bunk room. He had no pulse, no respirations, was cool to the touch, and had signs of lividity and rigor. Per emergency medical service protocol, the FF was pronounced dead on scene. The death certificate, completed by the County Coroner, listed the cause of death as "cardiac arrhythmia, due to myocardial infarction, as a consequence of severe arteriosclerotic heart disease." The autopsy revealed severe coronary atherosclerosis with evidence of acute plaque rupture with hemorrhage; these findings are consistent with an acute heart attack.

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.

Perform symptom-limiting exercise stress tests on firefighters at increased risk for CHD and sudden cardiac events.

Perform an annual physical performance (physical ability) evaluation.

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

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Introduction & Methods

On April 6, 2013, a 57-year-old male career FF suffered a fatal heart attack after responding to an automatic alarm shortly after midnight. NIOSH was notified of this fatality on April 7, 2013, by the U.S. Fire Administration. NIOSH contacted the affected fire department (FD) on April 17, 2013, and again on April 15, 2014, to obtain additional information and to schedule the investigation. On April 29, 2014, 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:

- Assistant Chief of Training
- Union President
- Crewmember who worked the 24-hour shift with the FF
- Crewmember who arrived at the fire station at 0700 hours on April 6, 2013 to begin his shift
- Pathologist who performed the autopsy

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

- Ambulance pre-hospital care report
- Death certificate
- Autopsy report
- Primary care physician (PCP) medical records
- FD medical records
- Written statement from a senior fire fighter who found the FF

Investigative Results

Incident. On April 5, 2013, a 57-year-old male career FF reported to the fire station at 0800 and began his 24-hour shift. The FF was the Acting Lieutenant for his three-person company. The FF and his crew responded to an emergency medical call just after 0830 hours, but were cleared from the scene because the patient had left. The crew was dispatched for a second emergency medical call at 1917 hours, but again the call was cancelled before patient contact was made. Other activities throughout the day included a meeting at headquarters and light cleaning chores at the fire station. After the second medical call, the FF spent much of the evening in the officer's bunk room although he did have ice cream with one of the crewmembers at around 2100 hours.

On April 6, 2013, at 0021 hours, the FD received an automatic fire alarm. The FF and his crew responded to a college fraternity house. They found the detector on the 5th floor of the five-story building had been activated. The FF climbed the five flights of stairs in full PPE and SCBA and investigated the area, where he found a burning cigarette. The crew was back in service at 0041 hours and returned to the station a few minutes afterward. As the FF returned to the station he was burping and attributed it to indigestion. Shortly after the crew returned to quarters, at approximately 0100 hours, the FF retired to the officer's bunk room.

The next morning, at 0656 hours the crew was dispatched to a medical alarm and the FF did not respond. His crew responded to the alarm but were cancelled en route. When they returned to the station, they knocked on the door of the bunk room. Not getting a response, they entered

Investigative Results (cont.)

the bunk room at approximately 0715 hours and found the FF in his bed dressed in his shorts. He was unresponsive, pulseless, apneic, and cool to the touch with dependent lividity and rigor. These signs suggest the FF had been deceased for several hours [Prahlow 2010]. Following established emergency medical service protocols, the FF was pronounced dead on scene.

Medical Findings. The death certificate completed by the County Coroner, listed the cause of death as "arrhythmia, due to myocardial infarction, as a consequence of arteriosclerotic heart disease." The autopsy, performed by a pathologist, revealed severe coronary artery atherosclerosis of the left descending coronary artery with ruptured plaque, and hemorrhage in plaque; these findings are consistent with an acute heart attack. See Appendix A for more detailed autopsy information.

The FF had numerous modifiable risk factors for coronary heart disease (CHD): an occasional smoker who recently quit, borderline high blood cholesterol, an elevated body mass index (BMI), and infrequent exercise. The FF rarely saw his private physician, but his FD medical evaluations showed total cholesterol levels ranging from 229 to 256 milligrams per deciliter (mg/dL) over the past 10 years (desirable < 200 mg/dL; borderline high 200-239 mg/dL). His last FD medical evaluation was in April 2012 when his blood cholesterol was 234 mg/dL and his blood pressure was 151/80 millimeters of mercury (mmHg) (treatment should be initiated at systolic>140mmHg or diastolic >90 mmHg [James et al. 2014]. At this visit he was 71 inches tall and weighed 218 pounds, giving him a BMI of 30.4 kilograms per meter squared [CDC 2014]. He was cleared for unrestricted fire fighting duty. Although the contractor for the FD does not currently offer stress tests, a stress test was offered to the FF in 2007 as part of a fitness program funded by a grant received by the FD. At that time, the FF reported that he had undergone a stress test by his PCP three months earlier, thus making the 2007 FD stress test unnecessary. At the time of this report, NIOSH was unable to find records of that stress test.

Description of the Fire Department

The FD consists of 120 uniformed personnel with five fire stations serving a population of approximately 50,000 residents in a geographic area of just over 10 square miles.

Hiring/Training. The FD requires all fire fighter candidates to complete an application and to take a civil service test. Individuals who perform well on the civil service test are offered a physical agility test. Potential candidates are selected for interviews based on their performance on the civil service test and their physical agility test scores. Once a provisional offer has been made, new hires must pass a background check, a psychological evaluation, and an occupational medical evaluation (discussed below). Newly hired fire fighters attend a 14-week training program at the Training Academy. The FF was certified as a Fire Fighter I and II and an emergency medical technician/paramedic and had 24 years of firefighting experience.

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Description of the FD (cont.)

Pre-placement Medical Evaluations. The FD requires a pre-placement medical evaluation for all fire fighter candidates. The pre-placement evaluation includes the following items:

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

Periodic Medical Evaluations. The FD requires annual medical evaluations for all fire fighters. Components of this evaluation are identical to the pre-placement evaluation with the following exceptions: (1) the chest X-ray is not required and (2) the drug screen is randomly administered. The FF's last FD medical evaluation was in April 2012 and he was cleared for full duty.

Medical Clearance and Fitness/Wellness Programs. Annual respirator fit tests as well as medical clearance to wear a respirator are required by the FD. A fire fighter injured at work must be evaluated and cleared for "return to work" by the occupational medicine contractor. A fire fighter who misses prolonged work due to an illness must provide a "return to work" note from his/her PCP. All fire houses have exercise (strength and aerobic) equipment but the FD does not offer a fitness program.

Discussion

Atherosclerotic 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 2014]. Risk factors for CHD include three non-modifiable factors (age older than 45, male gender, and family history of CHD) and six modifiable factors (diabetes mellitus, smoking, hypertension, high blood cholesterol, obesity, and physical inactivity [AHA 2014; National Cholesterol Education Program 2002]. The FF had three of these risk factors (gender, age, and infrequent exercise) and three borderline risk factors (high cholesterol, past history of smoking and elevated BMI).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2013]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion. Most heart attacks occur when a vulnerable plaque ruptures, causing a blood clot to form and occlude a coronary artery [Libby 2013]. Establishing a recent (acute) heart attack requires one or more of the following: characteristic electrocardiogram changes, elevated cardiac enzymes, or coronary artery thrombus. In this FF's case, a plaque rupture with hemorrhage was found at autopsy confirming an acute heart attack (myocardial infarction).

Physiological Stress of Firefighting. Firefighting is widely acknowledged to be physically demanding. Firefighting activities require fire fighters to work at near maximal heart rates for long periods. An increase in

Discussion (cont.)

heart rate typically occurs in response to the initial alarm and persists throughout the course of fire suppression activities [Barnard and Duncan 1975; Lemon and Hermiston 1977; Manning and Griggs 1983; Smith et al. 2001]. Even when energy costs are moderate (as measured by oxygen consumption) and work is performed in a thermoneutral environment, heart rates may be high (over 170 beats per minute) owing to the insulated properties of the personal protective clothing [Smith et al. 1995]. Furthermore, climbing stairs in PPE has been shown to be strenuous, with heart rates reaching nearly maximal levels after ascending five flights [Williams-Bell et al. 2009]. The FF responded to an automatic alarm in a student residential building just after midnight. In investigating the alarm he climbed five flights of stairs in full PPE, including SCBA and performned a search of the area. After the call, he complained of belching and indigestion.

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 FF's sudden cardiac death was the result of a fatal heart attack probably due to a combination of his undiagnosed heart disease, the alarm response, and the moderate physical exertion associated with climbing five flights of stairs in full PPE and SCBA.

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]

Discussion (cont.)

*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).

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 electrocardiogram, 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 FF had several risk factors for CHD and at autopsy was found to have severe atherosclerosis. The NFPA and AHA/ACC guidelines suggest an exercise stress test was appropriate given the FF's age (>45 years) and his other CHD risk factors. Had a recent stress test been performed, perhaps his underlying CHD could have been identified and subsequently 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: Perform symptom-limiting exercise stress tests on firefighters 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 FF had multiple CHD risk factors (male, age over 45 years, borderline high blood cholesterol, obesity, smoking, physical inactivity), therefore, an exercise stress test was warranted according to NFPA and AHA/ACC guidelines.

Recommendation #2: Perform an annual physical performance (physical ability) evaluation.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program 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 2013]. 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 #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 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 et al. 2013]. The FD does not have a wellness/fitness program. 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 = 430 grams (expected weight 384 grams) [Silver and Silver 2001]
  - Heart valves are unremarkable
  - Some patchy pallor in the interventricular septum, but no obvious scars
- Coronary arteries
  - Coronary arteries remarkable for about 80% stenosis in the left anterior descending coronary artery by soft and partially calcified plaque material
  - Stenosis is present about 3 cm from left coronary orifice
  - Severe atherosclerosis with ruptured plaque, and hemorrhage in plaque
  - Left circumflex coronary artery shows focal, about 50%, stenosis
  - Right coronary artery is patent

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