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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 *July, 2013*

Fire Apparatus Operator Found Unresponsive in Bunk Room After A Ladder Training Drill – Virginia

Executive Summary

On March 19, 2012, a 54-year-old male career fire apparatus operator (FAO) reported for duty and participated in a training drill that required climbing a 100-foot aerial ladder in full turnout gear and self contained breathing apparatus. The FAO easily climbed the ladder which took only about 2- 3 minutes. Upon returning to the base of the ladder, the FAO did not report any unusual symptoms and showed no signs of distress. Approximately 1 hour and 45 minutes later he was found unresponsive and pulseless on the floor near his bunk. Station members immediately began cardiopulmonary resuscitation and initiated advanced cardiac life support (ACLS). The FAO was transported to the local hospital's emergency department (ED) where resuscitation efforts were continued until the FAO was pronounced dead. The death certificate and autopsy report both listed the cause of death as "atherosclerotic and hypertensive cardiovascular disease." NIOSH investigators conclude that the FAO most likely died of a fatal arrhythmia.

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 (FD) across the country.

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

Introduction & Methods

On March 19, 2012, a 54-year-old career male FAO suffered an unwitnessed cardiac arrest within 2 hours of completing an aerial ladder climb. NIOSH was notified of this fatality on March 20, 2012, by the U.S. Fire Administration. NIOSH contacted the affected FD on March 26, 2012, and again on May 20, 2013, to obtain additional information and to schedule the investigation. On June 4-5, 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:

- Fire Chief
- Safety Chiefs (current and former Chief of Safety)
- Crew members on-duty with the FAO at the time of this incident (Captain at the station, his Lieutenant, and another firefighter)
- FAO's wife

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

- FD general operating procedures
- Ambulance pre-hospital care report
- Death certificate
- Medical examiner's report
- FD medical records
- Accident report prepared by the City
- FD incident report

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Investigative Results

Incident. On March 19, 2012, the FAO reported to work to begin a 24-hour shift at 0700 hours. His job responsibilities were primarily to drive the ladder truck at a station that housed an engine, a ladder truck, and an ambulance. The day began with a roll call line-up at which time the Captain announced that the day's events would include an aerial ladder climb prior to physical fitness training. The FAO left the line-up briefing and set up the aerial ladder in the rear of the station, extending it 100 feet at a 70-degree angle.At approximately 0800 hours, members began climbing the ladder wearing their bunker gear and self-contained breathing apparatus.

The FAO was the first member to climb the ladder, which took approximately 2 to 3 minutes. The FAO returned to the base of the aerial ladder and stayed in the turntable while his Lieutenant climbed the ladder. After the Lieutenant descended the ladder, the FAO indicated that he was going to put his gear away. Nothing out of the ordinary was noted during the aerial climb and the FAO reported no ill effects during or after he descended the ladder.

After members completed the climb, many participated in voluntary morning physical fitness training. The Captain encouraged participation and typically allowed time after roll call line-up. The FAO usually participated in these physical fitness training sessions, but did not participate on this morning. Shortly after 0945 hours, the Captain realized he had not seen the FAO since the morning ladder training. He asked another fire fighter if he knew the FAO's whereabouts and was told that the FAO was having chest discomfort/pain thought to be related to a possible chest cold.

With an added sense of urgency the Captain began searching for the FAO. Another fire fighter had seen the FAO about 15 minutes earlier in the hallway and noted that the FAO had complained of a cough from a chest cold. Fire fighters were instructed to check the bunk room and bathroom while the Captain and Lieutenant searched other areas (e.g., outside, back of the station, etc.). When the FAO was not quickly found, the Captain used the public announcement system to request that the FAO report to the galley. At approximately 1000 hours, a firefighter called the FAO's cell phone. The light and sound of the cell phone alerted station personnel that the FAO had collapsed on the floor, partially under his bunk. The FAO was unresponsive, pulseless, and apneic. Cardiopulmonary resuscitation was initiated as the resuscitation equipment was retrieved from the ambulance. A cardiac monitor was attached to the FAO and revealed pulseless electrical activity. At 1001 hours, the Captain notified dispatch that a fire fighter was down as members initiated ACLS measures including placement of a King Airway® for ventilation and an intravenous line for cardiac medications.

Neighboring engine and medic units arrived at 1008 hours and assumed patient care. The FAO still had no respiration, pulse, or heart rhythm. The medics swapped out the King Airway® for an endotracheal tube whose placement was confirmed by auscultation and capnography. ACLS continued on scene for a total of 33 minutes before the ambulance departed the fire station (1041 hours). The ambulance arrived at the local hospital's ED at 1049 hours. At 1104 hours chest compressions were discontinued and a cardiac ultrasound showed no cardiac activity. The FAO was pronounced dead at 1106 hours.

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Investigative Results (cont.)

Medical Findings. The death certificate and autopsy, both listed the cause of death as "Atherosclerotic and hypertensive heart disease." The autopsy noted concentric left ventricular hypertrophy and multifocal mild atherosclerosis with stenosis ranging from 20-30%. There was no evidence of an acute intracoronary thrombus. The medical examiner concluded that the death was likely due to a cardiac arrhythmia that he believed to be the result of atherosclerotic and hypertensive heart disease. See Appendix A for a more complete description of pertinent autopsy findings.

The FAO had the following risk factors for coronary heart disease (CHD): smoking (he smoked approximately a pack per day), and borderline high total cholesterol and borderline low-density lipoprotein (LDL) cholesterol identified since 1999 for which he has been following a low fat, low cholesterol diet. He also had high high-density lipoprotein (HDL) cholesterol (the "good" cholesterol) (> 60 mg/dL) which is considered a "negative risk factor", meaning that a higher number is associated with a lower risk of cardiovascular disease. His last lipid panel from May 2011 showed a total cholesterol of 215 milligrams per deciliter [mg/dL] (desirable is < 200; borderline high is 200-239 mg/dL) and a low-density lipoprotein (LDL) cholesterol of 140 mg/dL (optimal is < 100 mg/dL; near optimal/above optimal is 100-129 mg/dL; borderline high is 130-159 mg/dL). He was not known to have hypertension [his last blood pressure reading taken in May 2011 was 110/69 millimeters of mercury (optimal is < 120/80 millimeters of mercury). He did not have diabetes mellitus and was not obese (the FAO was 72 inches tall and weighed 208 pounds, giving him a body mass index (BMI) of 28.2 kilograms per meter squared [CDC 2013]. He had no known family history of cardiac disease and he exercised regularly.

Description of the Fire Department

At the time of the FAO's death, the FD consisted of just under 500 uniformed fire fighters and served a population of approximately 250,000 residents in a geographic area of approximately 54 square miles. The FD had 14 fire stations that housed 14 engine companies, 7 ladder companies, 2 rescue companies, and 12 medic units. In 2012, the FD responded to over 40,000 calls, including over 1,000 fire calls.

Hiring and Training. Applicants must be 18 years of age, possess a valid driver's license from Virginia or North Carolina, and have no history of felonies or drug use. Applicants must pass a written exam, physical ability test, and background check prior to being granted an interview. Candidates who are offered employment must pass a mandatory medical evaluation polygraph test and sign a no tobacco use contract. Newly hired fire fighters attend Recruit Academy for 8½ months (including EMT training) and are considered probationary firefighters for 1 year after they complete this training.

Preplacement 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
- Blood tests: complete blood count (CBC), chemistry panel which includes cholesterol and triglyceride measurements
- Urinalysis
- Urine drug test
- Spirometry (lung function tests)
- Resting electrocardiogram (ECG)

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Description of the FD (cont.)

- Chest x-ray
- Skin test for tuberculosis

Annual Medical Evaluations. The FD requires annual medical evaluations for all fire fighters. Components of this evaluation are identical to the pre-placement evaluation except that the drug screen is not required and chest x-rays are only performed every 5 years unless determined necessary by the evaluating physician. The FD performs stress testing as clinically indicated or on asymptomatic for firefighters beginning at the age of 45 years and every 5 years thereafter, unless the firefighter has two or more cardiovascular disease risk factors in which case stress tests are done more frequently. In 2007, when he turned 50 years old, the FAO performed the mandated exercise stress test. He exercised 13 minutes (1 minute into stage V) on a Bruce treadmill testing, giving him an estimated aerobic capacity of 14.5 metabolic equivalents (METS). During the test the FAO did not complain of any angina, had a normal blood pressure response, no arrhythmias, and no changes on electrocardiogram consistent with ischemia. His last FD medical evaluation was in May 2011 during which no major abnormalities were noted (although he was counseled regarding the importance of smoking cessation) and he was medically cleared for unrestricted duty.

Medical Clearance and Fitness/Wellness Programs. A fire fighter who suffers a major injury at work must be evaluated and cleared for "return to work" by a physician in the FD's medical clinic. All fire stations have exercise (strength and aerobic) equipment. Participation in fitness programs varies by station and shift. The city has a wellness program that includes nutritional counseling, smoking cessation, stress management, health risk assessment, and individual counseling; it is available to members of the FD.

Discussion

Coronary Heart Disease (CHD) and the Pathophysiology of Sudden Cardiac Death. The FAO was found unresponsive in the bunk room and most likely suffered an unwitnessed cardiac arrest. 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 [Libby 2008; AHA 2013]. When these plaques rupture, a blood clot can form and occlude the artery resulting in a heart attack [Shah 1997]. Although the FAO had several CHD risk factors (male gender, over 45 years old, smoker, and borderline high cholesterol), he had only mild atherosclerosis with relatively minor narrowing of his coronary arteries on autopsy. In addition, no blood clot (thrombus) was found in his coronary arteries, thus making a heart attack unlikely. More likely, the FAO suffered a primary cardiac arrhythmia. The only risk factor the FAO had for this condition is left ventricular hypertrophy (LVH).

Left Ventricular Hypertrophy (LVH). The autopsy revealed that the FAO had concentric LVH. 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 FAO was not known to be hypertensive and on autopsy had no evidence of valvular problems nor did he have moderate to severe atherosclerosis associated with chronic cardiac ischemia. Thus, the cause of the FAO's LVH is unclear. Regardless of the etiology, LVH is associated with an increased risk of sudden cardiac death [Levy et al. 1990].

Physiological Stress of Firefighting. Firefighting is widely acknowledged to be physically demanding. Firefighting activities require fire

Discussion (cont.)

fighters to work at near maximal heart rates for long periods. An increase in 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 insulative properties of the personal protective clothing [Smith et al. 1995].

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]. The FAO performed an aerial ladder climb as part of training approximately 2 hours before his collapse. The ladder climb in full bunker gear would be considered strenuous work even though it only took 2-3 minutes to complete. It is unclear what role, if any, climbing the ladder played in triggering the FAO's sudden cardiac event.

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: 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, and in Firefighter Fitness: A Health and Wellness Guide [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 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 has access to health promotion services through the City. Some thought should be given to ways to ensure that FD personnel feel comfortable to use these programs. The FD has a policy that bans tobacco use among FD personnel who have been hired recently; the FAO was hired before this policy went into place and he was grandfathered in under the old policy. The FD has policies that prohibit smoking in fire stations.

Recommendations (cont.)

The FD has a voluntary fitness program. NIOSH recommends a formal, mandatory fitness program to ensure all members receive the benefits of a physical fitness training.

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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/Structure
  - Heart weight = 473 grams
  - Concentric left ventricular hypertrophy with maximal thickness of 2 cm (normal by autopsy 0.76–0.88 cm [Colucci and Braunwald 1997]
- Coronary arteries
  - Multifocal mild atherosclerosis with stenosis ranging from 20-30% in the left anterior descending, right coronary and left circumflex coronary arteries
  - Noramlly distributed
  - No evidence of coronary thrombosis
- Microscopic examination
  - Scattered myocytes with nuclear hypertrophy
  - Patchy increased perivascular fibrous tissue
  - No acute hemorrhage or necrosis seen
- No drugs of abuse detected

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