Firefighter Suffers Fatal Cardiac Event While Assisting with a Medical Call – Illinois

Executive Summary

In December 2015, a 49-year-old male firefighter (FF) responded to a medical call. He drove an engine assigned to assist an ambulance. While doing chest compressions on a cardiac arrest victim, the FF complained of being tired. His lieutenant (LT) had him stop and sit down. The FF then complained of chest pain. The LT summoned another ambulance. On entering the ambulance, the FF became unresponsive. The ambulance crew began cardiopulmonary resuscitation and advanced life support. They transported the FF to the hospital emergency department. There, advanced life support care continued until the FF was pronounced dead.

The death certificate listed coronary artery thrombosis as the immediate cause of death and coronary atherosclerosis as the underlying cause of death. The autopsy revealed a thrombus that completely occluded the left anterior descending coronary artery. National Institute for Occupational Safety and Health investigators conclude that the emergency response and physical exertion of doing chest compressions triggered a heart attack.

Key Recommendations

- *Phase in a mandatory comprehensive wellness and fitness program for firefighters.*

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For further information, visit the program website at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).

2016
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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 September 1, 2016

Firefighter Suffers Fatal Cardiac Event While Assisting with a Medical Call – Illinois

Introduction

On December 4, 2015, a 49-year-old firefighter (FF) suffered a heart attack while performing cardiopulmonary resuscitation (CPR) on a cardiac arrest victim. The U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this fatality on December 7, 2015. NIOSH contacted the affected fire department (FD) on December 7, 2015 and again on June 20, 2016, to gather additional information and to initiate the investigation. On June 24, 2016, a contractor for the NIOSH Fire Fighter Fatality Prevention and Investigation Program (the NIOSH investigator) conducted an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- Lieutenant (LT) and FF on the engine crew on which the FF was working
- Paramedic on responding ambulance
- Union president
- FF's widow

NIOSH personnel reviewed the following documents:

- FD standard operating guidelines
- FD incident report
- FD injury/illness investigation report
- FD medical evaluation records
- Emergency medical service (ambulance) report
- Hospital emergency department (ED) records
- Death certificate
- Autopsy report

Investigation

On December 4, 2015, a 49-year-old male career FF reported for duty at 0700 hours. The FF was the engineer/driver on the engine. During the morning he participated in daily chores and responded to a minor medical call. At approximately 1440 hours, the engine and its crew were dispatched to assist the ambulance with a cardiac arrest at a retail store. CPR had been initiated by bystanders and the

ambulance crew took over patient care when they arrived. The FF and other members of the engine crew assisted the ambulance crew in loading the patient into the ambulance and assisted with patient care. The FF had been performing chest compressions for approximately 5–6 minutes when he stated that he was tired. His LT noticed that the FF's face was red and that he was sweating profusely. The LT had the FF take off his coat and sit down while another crew member took over compressions. The FF complained of chest pain. When the FF was asked if he thought chest pain was muscular in nature due to compressions. He did not have a clear answer. The LT had the FF step out of the ambulance into the cooler air (41°F, 85% humidity, winds out of the south at 9.2 miles per hour; wind chill of 36°F) [Weather Underground no date] and he called for a second ambulance. The LT stayed with the FF, noticing that the FF's color seemed to improve but he was agitated. The second ambulance arrived at 1457 hours. The FF walked to the ambulance, stepped into the back, and sat on the cot. Emergency medical services (EMS) personnel noted that he was alert and oriented but appeared pale and was sweating heavily. The FF reported that he had experienced substernal chest pain that radiated down his arm. Just as the FF finished his sentence, he began to have seizure like activity and became unresponsive. EMS personnel requested additional personnel and initiated CPR and advanced cardiac life support. The electrocardiogram (ECG) revealed pulseless electrical activity. Oxygen was provided by bag-valve mask. A King airway was secured and epinephrine was provided via an intraosseous line. The ambulance departed the scene at 1505 hours and arrived at the ED at 1510 hours.

The FF arrived at the ED with no pulse and in asystole (no heart rhythm). He was intubated and provided with cardiac medications but remained in asystole. Full cardiac life support measures were continued in the ED for over 30 minutes without change in clinical status. An ultrasound confirmed the absence of a spontaneous heart movement. At 1545 hours, CPR was discontinued and the FF was pronounced dead.

Medical Findings

The death certificate and autopsy reports were completed by the County Medical Examiner. They identified a large intracoronary thrombus in the left anterior descending coronary artery as the cause of death due to underlying coronary atherosclerosis and noted obesity as a contributing condition. The autopsy revealed approximately 70% narrowing of the left anterior descending artery due to atherosclerotic plaque, a slightly enlarged heart (467 grams), and left ventricular hypertrophy (1.5 centimeters [cm]). See Appendix A for a more detailed description of autopsy findings.

The FF had a history of hypertension, hyperlipidemia, and hyperglycemia, and ongoing gastric reflux and heartburn. He also had several bouts of sinus infections and bronchitis and orthopedic problems over the past 3 years. The FF regularly saw a primary care physician (PCP) to monitor and treat his medical conditions. He was taking medication for hypertension, but was not taking medication for hyperlipidemia or hyperglycemia. At his last PCP visit on September 9, 2015 (a follow-up visit for bronchitis and acute sinusitis), his blood pressure was 130/100 millimeters of mercury (mmHg) (normal resting systolic is 90–119 mmHg and normal resting diastolic is 60–79 mmHg).

The FF experienced chest pains in January 2015 and was admitted to the hospital for evaluation. Blood work revealed troponin and d-dimer values (enzymes used as markers of a heart attack) that were

within normal limits. A chest X-ray found normal sized heart and vessels and no acute cardiopulmonary findings. An echocardiogram reported normal left ventricular size (although the measurements recorded in the results include a normal left ventricular wall size [.8 cm] and a thickened septal wall [1.8 cm]) and normal systolic function with a normal ejection fraction of 60%–65%. A myocardial perfusion study found no significant perfusion defects. The FF completed an exercise stress test (EST) using the Bruce protocol and exercised for 9 minutes (attaining approximately 10 metabolic equivalents [METs]), achieving a maximal heart rate of 92 beats per minute (bpm) (87% of age-predicted maximum). The EST was negative for angina symptoms and diagnostic ischemic ECG changes.

The FF had his last FD medical evaluation in July 2015. At that time, laboratory tests showed a total blood cholesterol of 142 milligrams per deciliter (mg/dL) (desirable < 200 mg/dL), triglycerides of 141 mg/dL (normal < 150 mg/dL), high-density lipoprotein (HDL) cholesterol of 38 mg/dL (normal > 40 mg/dL) [NCEP 2002], and blood glucose of 106 mg/dL (normal 70–100 mg/dL). The FF was cleared for full firefighting duty.

The FF was a non-smoker with a family history of cardiovascular disease. He had recently been involved in a work hardening program for a shoulder injury. Based on autopsy, he was 71 inches tall and weighed 262 pounds, giving him a body mass index of 36.5 kilograms per meter squared [CDC 2015].

Fire Department

At the time of the NIOSH investigation, the FD consisted of approximately 30 uniformed personnel working out of two fire stations. It served a population of approximately 20,000 in a geographic area of 18 square miles. In 2015, the FD responded to over 3,500 incidents, including 1,460 fire calls and more than 2,000 rescue and emergency medical calls.

Employment and Training

Applicants must be between 21–35 years of age; have a high school diploma or a general education development (GED) diploma; have a valid state driver's license; and possess a paramedic license. Applicants take a written exam and top scorers are invited to an oral examination. Once a conditional offer to hire is given, the candidate must pass a background check, a psychological evaluation, and a medical evaluation. A new member must complete training to the Operation Level (state equivalent of Firefighter I and II). New members are placed on a 24-hour shift (24 hours on duty, 72 hours off duty) and are on probation for 1 year. The FF was certified as a Firefighter II and driver/operator and was a licensed paramedic. He had been a FF for 25 years and had been employed by his current FD for 13 years.

Preplacement and Periodic Medical Evaluations

The City requires preplacement medical evaluations for all applicants. Evaluations are conducted by a contract occupational medical group. Components of this evaluation include the following:

- Complete medical history
- Physical examination (height, weight, blood pressure, pulse, and respiratory rate)
- Complete blood count with lipid panel
- Urinalysis
- Urine drug screen
- Audiogram
- Vision test
- Respirator use questionnaire
- Spirometry
- Resting ECG
- Chest x-ray

Periodic medical evaluations are provided annually to all members and contain the same components listed above except that a drug screen is not performed on all FFs. Once the medical evaluation is complete, the contracted health care provider makes a determination regarding medical clearance for firefighting duties and forwards this decision to the FD office. The contracted health provider also makes determinations on return to work after an injury or illness.

Wellness/Fitness Programs

The FD does not have a comprehensive wellness/fitness program as recommended by the International Association of Fire Fighters, International Association of Fire Chiefs (IAFF/IAFC) Wellness Fitness Initiative [IAFF, IAFC 2008]. The FD has exercise equipment available in the stations and allows firefighters to work out in the afternoon.

Discussion

Sudden Cardiac Events

In the United States, atherosclerotic coronary heart disease is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development are grouped into non-modifiable and modifiable. Non-modifiable risk factors include age older than 45, male gender, and family history of coronary artery disease. Modifiable risk factors include diabetes mellitus, smoking, high blood pressure, high blood cholesterol, and obesity/physical inactivity [AHA 2015; NHLBI no date]. The FF had hypertension, hyperlipidemia, and hyperglycemia; he was obese (on the basis of his body mass index measurement of 36.5).

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. 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. This sudden blockage is primarily due to blood clots (thromboses) forming on top of atherosclerotic plaques [Libby 2013]. Establishing a recent (acute) heart attack requires any of the following: characteristic ECG changes, elevated cardiac enzymes, or coronary artery thrombus. In this case, the FF had a thrombus that occluded the left anterior descending coronary artery.

Firefighting and Sudden Cardiac Death

Heart attacks and sudden cardiac death can be triggered by heavy physical exertion [Albert et al. 2000, Mittleman 1993; Willich 1993]. Among firefighters, sudden cardiac events have been associated with or triggered by alarm response, fire suppression, and heavy exertion during training (including physical fitness training) [Kales et al. 2003, 2007; NIOSH 2007]. In response to a medical call, the FF helped load the patient into the ambulance and provided chest compressions for 5–6 minutes. NIOSH concludes that the emergency response and physical exertion of doing chest compressions triggered a heart attack.

Left Ventricular Hypertrophy

On autopsy, the FF was found to have LVH with the left ventricular wall measuring 1.5 cm. Hypertrophy of the heart's left ventricle is a relatively common finding among individuals with long-standing hypertension, a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle) [Siegel 1997]. Left ventricular hypertrophy (LVH), one aspect of hypertensive cardiovascular disease, is associated with increased risk for sudden cardiac death [Levy et al. 1990]. In this case, the FF had had an echocardiogram 15 months earlier. In that exam, the physician reported no evidence of left ventricular hypertrophy despite a left ventricular wall thickness of 0.8 cm and a septal wall thickness of 1.8 cm (normal 0.6–1.0 cm). It is unclear why the left ventricular wall was measured as 0.8 cm via echocardiography only 15 months prior to the fatal incident. This may have been due to technical difficulties in imaging the heart or it may reflect rapid changes in left ventricular wall thickness.

Occupational Medical Standards for Structural Firefighters

To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among firefighters, 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 the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. The FF had his last yearly medical exam in July 2015. In the absence of significant findings, he was cleared for full firefighting duty.

Recommendations

Recommendation #1: Phase in a mandatory comprehensive wellness and fitness program for firefighters.

Although the FD has extensive exercise equipment in both stations and provides time for firefighters to exercise, it does not have a mandatory wellness/fitness program. 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 U.S. Fire Administration *Health and Wellness Guide for the Volunteer Fire and Emergency Services*, and in *Firefighter Fitness: A Health and Wellness Guide* [IAFF, IAFC 2008; NFPA 2015; Schneider 2010; USFA 2009]. 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 workdays [Aldana 2001; Stein et al. 2000]. Fire service health promotion programs have been shown to reduce coronary heart disease risk factors and improve fitness levels, with mandatory programs showing the most benefit [Blevins et al. 2006; Dempsey et al. 2002; Womack et al. 2005]. 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 et al. 2013].

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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. Wendi Dick, MD, MSPH, provided medical consultation and contributed to the report. Dr. Dick is Medical Officer for the Cardiac/Medical Fatalities Component in Cincinnati.

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Appendix A
Autopsy Findings

- Atherosclerotic Cardiovascular Disease
    - Proximal aspect of the left anterior descending coronary artery is occluded by an intraluminal thrombosis
    - 70% luminal narrowing of left anterior descending coronary artery due to atherosclerosis
- Cardiomegaly with left ventricular dilation (heart weighed 467 grams; predicted normal weight is 425 grams [ranges between 322 and 561 grams as a function of sex, age, and body weight]) [Silver and Silver 2001]
    - Left ventricular wall thickness (1.5 cm)
        - Normal at autopsy is 0.76–0.88 cm [Colucci and Braunwald 1997]
        - Normal by echocardiographic measurement is 0.6–1.0 cm [Connolly and Oh 2012]
    - Interventricular wall thickness (1.2 cm)
- Pulmonary congestion and edema
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Negative blood test for drugs and alcohol

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