Firefighter/Paramedic Dies of Sudden Cardiac Event at Home Following Shift—Illinois

Executive Summary

On January 10, 2016, a 56-year-old male career firefighter/paramedic (FF/P) worked a 24-hour shift. He responded to several calls including a vehicle fire, medical call, and activated alarm. The following day, he worked with the Fire Prevention bureau for over 6 hours. In the evening, the FF/P shoveled snow at his home and then went to his bedroom. His family found him unresponsive in his bed 10–15 minutes later. They started cardiopulmonary resuscitation (CPR). Emergency medical services (EMS) found the FF/P unresponsive, pulseless, and not breathing. He was in asystole (no heart rhythm). On scene and enroute to the emergency department (ED), EMS provided CPR and advanced cardiac life support measures. ED staff treated the FF/D without success for 35 minutes and pronounced him dead at 2147 hours.

The autopsy report listed hypertensive-arteriosclerotic cardiovascular disease as the immediate cause of death. The report listed diabetes mellitus and obesity as contributing conditions. Autopsy findings included cardiomegaly, biventricular myocardial thickening, and left ventricular dilation. Two main arteries had calcified atherosclerotic plaque. The left anterior descending artery had significant stenosis. National Institute for Occupational Safety and Health (NIOSH) investigators concluded that the physical stress of shoveling snow likely triggered the sudden cardiac event. Given his uncontrolled diabetes mellitus and other cardiovascular disease risk factors, a more careful evaluation for fitness for firefighting duty, including a full medical evaluation consistent with National Fire Protection Association (NFPA) 1582 was needed.

Key Recommendations

- *Ensure that all firefighters receive an annual medical evaluation consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.*
- *Incorporate exercise stress tests (ESTs) into the fire department medical evaluation program for firefighters at increased risk for coronary heart disease.*
- *Phase in a mandatory comprehensive wellness and fitness program for firefighters.*
- *Perform an annual physical performance (physical ability) evaluation.*

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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).

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Introduction

On January 11, 2016, a 56-year-old firefighter/paramedic (FF/P) suffered a cardiac arrest at his home after shoveling snow. He had been on duty earlier that day in the Fire Prevention office and prior to that he had been on duty for a 24-hour shift. The U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this fatality on January 12, 2016. NIOSH contacted the affected fire department (FD) on January 15, 2016 and again on June 20, 2016, to gather additional information and to initiate the investigation. On August 1, 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
- Deputy Chief
- Union President
- Firefighter/paramedic serving with the FF/P
- FF/P's wife

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 January 10, 2016, a 56-year-old male career FF/P reported for a 24-hour shift and was assigned to drive an Engine. The FF/P performed the daily check of the engine and his self-contained breathing

apparatus and participated in typical house cleaning and chores. At 1304 hours the FF/P, the lieutenant (LT), and another FF were dispatched to an activated residential fire alarm. The call was cancelled enroute. At 1708 hours the engine crew responded to a vehicle fire. The FF/P helped advance a 1¾-inch hoseline to extinguish the fire, overhaul the vehicle, and reload the hose. The crew cleared the scene at 1738 hours.

At 1801 hours the engine crew responded to an ambulance assistance call in an apartment building with a patient on the 4th floor. The FF/P assisted with retrieving and carrying medical equipment up the stairs. As they ascended the stairs, the LT noticed that the FF/P was short of breath, so the two of them stayed on the 3rd floor waiting for information/requests from the ambulance crew while the second FF went to the 4th floor and assisted the ambulance crew. When questioned about how he was doing, the FF/P responded that he was fine and that he just needed a minute to catch his breath. The LT attributed the response to the extremely cold weather (8°F, winds out of the west at 12.7 miles per hour (mph), wind chill of -8°F) [Weather Channel 2016]. A short time later the FF/P carried medical equipment back to the engine and assisted the ambulance crew with patient care. The call was terminated at 1818 hours. Back at the fire station after the call, the other FF noticed that the FF/P seemed out of breath and asked him if he was okay. The FF/P responded that he was fine. The LT spoke with the FF/P at around 2315 hours. Again, the FF/P reported that he was fine.

At 0615 hours the engine crew responded to an activated fire alarm. The FF/P stayed with the engine while the LT investigated the alarm. At 0637 hours they were cleared from the call. At 0730 hours, the FF/P was relieved of duty. He reported to the Fire Prevention office where he worked on a plan review and other fire prevention activities until 1345 hours.

The FF/P arrived home after 1500 hours and spent the afternoon doing activities around the house including working on the computer, fixing a cord for an electronic devise, etc. He had dinner with his family and in the evening, he went outside and cleared snow (< 1 inch) from the front walkway. The family noticed nothing out of the ordinary. At approximately 2050 hours he entered his house and went to his bedroom. Approximately 10 minutes later his wife found him on his back on the bed in an unresponsive state. Family called 911 and initiated cardiopulmonary resuscitation (CPR). The ambulance was dispatched at 2105 hours and arrived on-scene at 2109 hours. Emergency medical services (EMS) personnel found the FF/P unresponsive, pulseless, and not breathing. His pupils were fixed and dilated. EMS took over CPR, obtained an airway (King airway), and provided oxygen via bag-valve mask. The cardiac monitor revealed asystole. Paramedics inserted an intraosseous line and provided cardiac medications. The ambulance departed the scene at 2120 hours and arrived at the emergency department (ED) at 2124 hours.

In the ED the FF/P remained in asystole. An endotracheal tube was inserted. An ultrasound confirmed no heart activity. At 2142 hours, the FF/P was pronounced dead.

Medical Findings

The County Medical Examiner office completed the death certificate. It listed hypertensive

arteriosclerotic cardiovascular disease as the immediate cause of death, and diabetes mellitus and obesity as significant conditions contributing to death but not resulting in the underlying cause. The autopsy revealed cardiomegaly (683 grams), biventricular myocardial hypertrophy (left ventricular thickness of 1.5 centimeter [cm]), left ventricular dilation, and coronary artery atherosclerosis, including calcified plaque in the right coronary artery and the left anterior descending artery. The left anterior descending artery had luminal narrowing of 80% due to plaque. See Appendix A for a more detailed description of autopsy findings.

The FF/P had a history of diabetes mellitus and high cholesterol. At his last FD medical evaluation in February 2015, he completed an Occupational Safety and Health Administration (OSHA) Respiratory Medical Evaluation Questionnaire and indicated that he was a smoker and had diabetes. The FF/P reported that he was taking oral medication to control his diabetes. The record also notes that the FF/P had taken Lipitor, a cholesterol lowering drug. He also stated that he had no cardiovascular or heart symptoms and denied having shortness of breath or chest pain with exertion. His blood pressure was 133/91 millimeters of mercury (mmHg) (normal resting systolic is 90–119 mmHg and normal resting diastolic is 60–79 mmHg). A pulmonary function test (spirometry) indicated moderate obstructive disease. The FF/P was 77 inches tall and weighed 330 pounds, giving him a body mass index of 39.1 kilograms per meter squared [CDC 2015]. No blood work was performed. The occupational medicine physician noted that the FF/P had non-insulin diabetes mellitus (with last known hemoglobin A1C of 7.7% (normal is < 5.7%), that the FF/P reported having a stress test 5 years ago, and that he was a current smoker with evidence of moderate obstructive disease. Based on these observations, the physician encouraged the FF/P to follow up with his primary care physician (PCP) regarding smoking cessation, diabetes control, and abnormal spirometry. On the basis of his risk factors for heart disease, the physician further advised the FF/P that his PCP may wish to conduct an EST. We requested but did not receive medical records from the FF/P's PCP. The FF/P was cleared for full firefighting duty.

Fire Department

At the time of the NIOSH investigation, the FD consisted of 63 uniformed personnel working out of three fire stations. It served a population of approximately 52,000 in a geographic area of 4.5 square miles. In 2015, the FD responded to approximately 6800 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 made, 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 spend 2 weeks on day shifts to be oriented to the policies and procedures of the FD before being placed on a 24-hour shift (24 hours on duty, 48 hours off duty). The new member is on probation for 1 year. The FF/P was certified as a Firefighter III and driver/operator and was a licensed paramedic. He had been with the FD for 28 years.

Preplacement Medical Evaluation

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

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

Periodic medical evaluations provided annually to all members includes:

- Medical history
- Physical examination (height, weight, blood pressure, pulse, and respiratory rate)
- Audiogram
- Vision test
- Respirator use questionnaire
- Spirometry

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 FF/P had yearly medical evaluations.

Wellness/Fitness Programs

The FD does not have a comprehensive wellness/fitness program as recommended by the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) (IAFF/IAFC) Wellness Fitness Initiative [IAFF, IAFC 2008]. The FD has exercise equipment available for its members and FF are permitted to exercise on duty. Nonetheless, NIOSH recommends a mandatory

wellness/fitness program to ensure all members receive the benefits of a wellness/fitness program. Fellow firefighters report that the FF did not engage in fitness activities at the fire station.

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 2016; NHLBI 2016]. The FF/P had four of the modifiable risk factors.

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]. Heart attacks and sudden cardiac death can be triggered by heavy physical exertion [Albert et al. 2000; Mittleman et al. 1993; Willich et al. 1993], including snow shoveling [Franklin et al. 2001] and firefighting activity [Kales et al. 2003, 2007; NIOSH 2007].

Establishing the occurrence of an acute heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes, or coronary artery thrombus/plaque rupture. In this case, the FF/P did not have an EKG because he never regained a heart rhythm, cardiac enzyme testing was not performed (but we would not expect the enzymes to become positive for at least 4 hours post-heart attack), and no coronary artery blood clot/plaque rupture was found at autopsy. Occasionally (16%–27% of the time) post-mortem examinations do not reveal the coronary artery blood clots/plaque rupture during acute heart attacks [Davies 1992; Farb et al. 1995]. The clinical scenario of this FF/P's death is consistent with a heart attack or a primary cardiac arrhythmia [Libby 2005; Thaulow et al. 1993]. Hypertension, left ventricular hypertrophy, cardiomegaly, coronary heart disease, smoking, and diabetes all increase the risk of an arrhythmia causing sudden cardiac death [AHA 2014; Haider et al. 1998; Mayo Clinic 2016; Verdecchia et al. 1998].

Cardiomegaly/Left Ventricular Hypertrophy

On autopsy, the FF/P had an enlarged heart (cardiomegaly), left ventricular dilation, and thickening (hypertrophy) of the heart wall. Cardiac dilation is an increased volume of any cardiac chamber or combination of chambers, usually leading to an increased size of the heart. Causes are varied but cardiac dilation is typically caused by cardiomegaly or myocardial hypertrophy [Siegel 1997a]. Hypertrophy of the heart's left ventricle (LVH) is a common finding among individuals with long-standing high blood pressure (hypertension), a heart valve problem, or cardiac ischemia (reduced blood supply to the heart muscle) [Siegel 1997b; Tavora et al. 2012]. LVH and cardiomegaly are both structural heart changes that increase the risk for arrhythmias and sudden cardiac death [Tavora et al. 2012].

Diabetes Mellitus

The voluntary National Fire Protection Association standard NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments*, provides guidance for fire department physicians when treating firefighters with diabetes [NFPA 2013a]. The standard states that firefighters 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:

- has had hemoglobin A1C measured at least 4 times a year over the last 12 months prior to evaluation if the diagnosis of diabetes has been present over 1 year
- if on oral hypoglycemic agents, has had no episodes of severe hypoglycemia (defined as requiring assistance of another in the preceding year)
- has achieved a stable blood glucose as evidenced by hemoglobin A1C level less than 8% during the prior 3-month period
- has a dilated retinal exam by a qualified ophthalmologist or optometrist that shows no higher grade of diabetic retinopathy than microaneurysms
- has normal renal function on the basis of a calculated creatinine clearance greater than 60 milliliters per minute and absence of proteinuria
- has no autonomic or peripheral neuropathy
- has normal cardiac function without evidence of myocardial ischemia on cardiac stress testing (to at least 12 METs) by EKG and cardiac imaging.

The FF/P had uncontrolled diabetes; he reported his hemoglobin A1C to be 7.7% in 2015. Although the occupational physician requested that the FF/P follow-up with his PCP, documentation of controlled blood glucose levels was not evident in the annual medical exam records. NFPA 1582 guidance recommends such documentation.

Occupational Medical Standards for Structural Firefighters

NFPA 1582 provides guidance on the components of a preplacement and annual medical evaluation and medical fitness for duty criteria [NFPA 2013a]. The FF/P had yearly FD medical evaluations, but the medical evaluation did not require all the components of the NFPA 1582 Standard. Despite his history of uncontrolled diabetes mellitus, a history of hypercholesterolemia, and the presence of other cardiovascular disease risk factors he was cleared for duty. The information available to the NIOSH investigator suggests that the firefighter should not have been cleared for duty without additional testing according to NFPA 1582 guidance.

ESTs can be used to screen for and identify occult coronary heart disease (CHD). However, recommendations for conducting ESTs on asymptomatic individuals without known heart disease are varied. The following paragraphs summarize the positions of widely recognized organizations on this topic.

NFPA 1582 recommends an EST be performed "as clinically indicated by history or symptoms" and refers the reader to its Appendix A [NFPA 2013a]. 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 firefighter's aerobic capacity. Maximal (i.e., symptom-limiting) stress tests with imaging should be used for firefighters 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)

Risk factors are defined as hypercholesterolemia (total cholesterol greater than 240 milligrams per deciliter), hypertension (diastolic blood pressure greater than 90 mmHg), 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 [ACC/AHA 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., firefighters)
    - 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 CHD
- 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 FF/P was older than 45 years of age, had diabetes mellitus, and had multiple risk factors for CHD. Given these conditions, a symptom limiting EST was indicated according to the positions of several widely recognized organizations. Although the occupational physician conducting the FD medical evaluation recommended that the FF/P discuss a treadmill test with his physician, the FF/P was cleared for duty without it. Had a symptom limited exercise test been performed perhaps his coronary artery disease could have been detected and treated.

Recommendations

Recommendation #1: Ensure that all firefighters receive an annual medical evaluation consistent 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 1582 and in the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative [IAFF, IAFC 2008; NFPA 2013a]. These evaluations are performed to determine a firefighter's medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. This medical evaluation should be consistent with the requirements of NFPA 1582 and should include screening testing for coronary artery disease in individuals with cardiovascular disease risk factors and should include appropriate testing for individuals with diabetes mellitus before they are cleared for duty.

Recommendation #2: Incorporate ESTs into the fire department medical evaluation program for firefighters at increased risk for coronary heart disease.

NFPA 1582, the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, and the ACC/AHA recommend an EST for male firefighters older than 45 with one or more coronary artery disease risk factors [ACC/AHA 2002; IAFF, IAFC 2008; NFPA 2013a]. The FF/P was over the age of 45 and had multiple risk factors for coronary heart disease (high blood pressure, diabetes mellitus, obesity, and high cholesterol). A symptom-limiting ESTs may have identified his underlying coronary artery disease.

Recommendation #3: Phase in a mandatory comprehensive wellness and fitness program for firefighters.

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]. The FD does not have a wellness/fitness program. The FD has exercise equipment available for its members and FF are permitted to exercise on duty. Nonetheless, NIOSH recommends a mandatory wellness/fitness program to ensure all members receive the benefits of a wellness/fitness program.

Recommendation #4: Perform an annual physical performance (physical ability) evaluation.

NFPA 1500 recommends fire department members who engage in emergency operations be annually evaluated and certified by the FD as having met the physical performance requirements identified in paragraph 10.2.3 of the standard [NFPA 2013b]. This is recommended to ensure firefighters are physically capable of performing the essential job tasks of structural firefighting. The physical ability test could be performed as part of the FD's annual training 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. Dr. Wendi Dick, Team Lead for Cardiac and Medical LODD Investigations, provided medical consultation and contributed to the report.

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Appendix A

Autopsy Findings

- Hypertension (clinical history)
    - Cardiomegaly with left ventricular dilation (heart weighed 683 grams; predicted normal weight is 479 grams [ranges between 363 and 633 grams as a function of sex, age, and body weight]) [Silver and Silver 2001]
    - Left ventricular wall – 1.5 cm
        - Normal at autopsy is 0.76–0.88 cm [Colucci and Braunwald 1997]
    - Right ventricular wall – 0.8 cm
        - Normal at autopsy is 0.2–0.7 cm with an average of 0.35–0.39 cm [Hutchins and Anaya 1973; Murphy et al. 1988]
    - Left ventricular chamber dilation (5.0 cm)
- Coronary artery and aortic atherosclerosis
    - Calcified atherosclerosis in right coronary artery and left anterior descending coronary artery
    - 60% stenosis of the right coronary artery
    - 80% stenosis of the left anterior descending coronary artery
- Mild to moderate atherosclerotic plaque in descending aorta
- Cholesterolosis of the gallbladder
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Negative blood test for drugs of abuse

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