Fire Fighter Suffers Cardiac Arrest While Driving Home From Fire Station After Responding to Motor Vehicle Accident – Illinois

Executive Summary

On February 7, 2017, a 46-year-old male volunteer FF (fire fighter) responded to a motor vehicle accident as the driver of the engine. Upon returning to the fire station after the call, the FF reported to his Chief that he was not feeling well and left the station before other members. Approximately 4 minutes later, as he was driving home in his privately owned vehicle, he lost consciousness and his vehicle struck other vehicles. Members of the FF's department, including paramedic-level EMS (emergency medical services) personnel, responded and initiated CPR (cardiopulmonary resuscitation). An ambulance was dispatched at 0049 hours and arrived on scene at 0105 hours. The FF received advanced cardiac life support care on scene and en route to the emergency department and regained a pulse several times. Hospital emergency department personnel continued resuscitation efforts until 0152 hours, when the FF was pronounced dead.

The autopsy report listed the immediate cause of death as atherosclerotic cardiovascular disease and listed diabetes mellitus, hypertensive cardiomegaly, and obesity as significant conditions contributing to his death. The report documented atherosclerosis with calcification and 95% stenosis (narrowing) of the left anterior descending and right coronary arteries. No coronary artery thrombi were found. NIOSH investigators conclude that the physical stress of the emergency response may have triggered the sudden cardiac event.

The motor vehicle accident was the first emergency the FF had responded to after being off duty for 3 months to recover from an injury to his leg. At the time of his death, he was being treated for type 2 diabetes, hypertension, high triglycerides, and obstructive sleep apnea. Approximately 7 months prior to his death, he was treated for a cholesterol embolism in his foot.

Key Recommendations

- *Ensure that all fire fighters receive an annual medical evaluation consistent with National Fire Protection Association (NFPA) 1582,* Standard on Comprehensive Occupational Medical Program for Fire Departments
- *Ensure 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.*

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The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH Fire Fighter Fatality Investigation and Prevention Program, which examines line-of-duty deaths or on-duty deaths of fire fighters to assist fire departments, fire fighters, the fire service and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with state or federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the victim, the fire department, or those interviewed. The NIOSH report's summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency's recommendations and is not intended to be definitive for purposes of determining any claim or benefit.

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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Death in the line of duty...

NIOSH Fire Fighter Fatality Investigation and Prevention Program

A summary of a NIOSH fire fighter fatality investigation July 1, 2017

Fire Fighter Suffers Cardiac Arrest While Driving Home From Fire Station After Responding to Motor Vehicle Accident – Illinois

Introduction

On February 8, 2017, a 46-year-old male volunteer FF suffered a sudden cardiac arrest as he was driving home in his POV (personally owned vehicle) after responding to an MVA (motor vehicle accident). The U.S. Fire Administration notified NIOSH of this fatality on February 9, 2017. NIOSH contacted the affected fire department (FD) on February 9, 2017, and again on June 8, 2017, to gather additional information and to initiate the investigation. On June 15, 2017, a contractor for the NIOSH Fire Fighter Fatality Prevention and Investigation Program (the NIOSH Investigator) conducted an on-site investigation of the incident.

The NIOSH Investigator interviewed the following people:

- Fire Chief
- A member of the FD
- Widow of the FF

The NIOSH Investigator examined the following documents:

- FD incident report
- FD medical evaluation records
- Personal physician records
- Previous hospital records
- EMS (ambulance) report
- Hospital ED records
- Death certificate
- Autopsy report

Investigation

On February 7, 2017, a 46-year-old male volunteer FF reported to the fire station at 1830 hours for monthly training and a business meeting. The FF participated in routine maintenance on the trucks and performed inventory checks. At 1945 hours, the FF had dinner with the other members as they conducted their monthly business meeting. At 2130 hours, the business meeting concluded and the FF went home. At 2348 hours, members received an alert over their radios for an MVA with injuries. The FF responded from home, drove his POV to the station, and then drove the engine that responded to

the scene. Other FD members packaged the patient for transport by the responding ambulance, and the FF used the hoseline to wash down the road and apply water around the vehicle involved in the accident. The FD cleared the scene of the accident and returned to quarters. At approximately 0044 hours, as members were putting the apparatus back in service, the FF reported to his Chief that he was not feeling well and left the station before other members. About 4 minutes later, as he was driving home in his POV, the FF lost consciousness and his vehicle struck other vehicles.

The FD received the call of the accident involving the FF at 0048 hours. The Fire Chief was the first member on-scene and found the FF unresponsive in the front seat of his POV. Fire fighters found the FF unconscious, cyanotic, and pulseless, and initiated CPR. An AED (automated external defibrillator) was attached to the FF and a shock was advised and delivered twice. When paramedics/fire fighters arrived on scene, they found the FF unresponsive, cyanotic, apneic, pulseless, cool, and dry. They placed him on a cardiac monitor, which showed a junctional rhythm at 70 bpm (beats per minute). (A junctional rhythm occurs when a backup pacemaker takes over because the heart's normal pacemaker is not functioning.) The FF's oral cavity and airway were suctioned, and ventilation was provided via bag-valve mask. Attempts to insert a Combitube® esophageal/tracheal airway were unsuccessful. Cardiac medications were administered. The FF remained breathless and pulseless, and the cardiac monitor showed PEA (pulseless electrical activity). Paramedics noted that the FF's pupils were fixed.

An ambulance was dispatched at 0049 hours and arrived on scene at 0105 hours. The FF was lifted onto the stretcher via a backboard and loaded into the ambulance. The FF was not breathing, had no pulse, and the cardiac monitor showed a junctional rhythm at 40 bpm. Additional suctioning of the airway was necessary. Epinephrine was administered, and the FF regained a pulse at 94 bpm. Assisted ventilations were continued. His pulse rate slowed and then was lost. Another round of epinephrine was given and the FF regained a pulse at 161 bpm. An attempt to intubate was unsuccessful, but a Combitube was inserted and correct placement was confirmed by good lung sounds and absent epigastric sounds. A 12-lead EKG (electrocardiogram) was obtained, showing atrial fibrillation. The FF lost his pulse again and another round of epinephrine was administered. The FF regained a pulse at 116 bpm. He was found to be hypotensive, with a blood pressure of only 88/50 mm Hg (millimeters of mercury; normal is in the range of 90–119 over 60–79 [NHLBI 2010, 2015]). Assisted ventilations continued until the ambulance arrived at the ED at 0126 hours and care was transferred.

In the ED the FF remained unresponsive and hypotensive. Within minutes, he lost his pulse again, and epinephrine was administered. Throughout treatment at the hospital ED, four rounds of epinephrine were administered. The Combitube was removed and the FF was intubated. Blood work revealed that the FF was severely hyperglycemic. Ultrasound was performed and found no organized cardiac activity. At 0152 hours, resuscitation efforts were discontinued and the FF was pronounced dead.

Medical Findings

The autopsy report completed by a forensic pathologist listed the immediate cause of death as atherosclerotic cardiovascular disease. Diabetes mellitus, hypertensive cardiomegaly, and obesity were listed as significant conditions contributing to his death. The report detailed calcified atherosclerotic

plaque that created 95% stenosis of the left anterior descending and right coronary arteries. The endocardial surface was smooth and had no evidence of thrombi or inflammation. The myocardium had no gross evidence of ischemic changes. The heart was enlarged, weighing 530 grams (predicted weight 453 grams). The wall of the left ventricle showed hypertrophy, measuring 1.5 centimeters (cm) thick (normal at autopsy is 1.07–1.39 cm according to Kitzman et al. [1988]). See Appendix A for a more detailed description of autopsy findings.

The FF had multiple risk factors for coronary artery disease, including smoking, diabetes, hypertension, high triglycerides, obstructive sleep apnea, and obesity. He was 75 inches tall and weighed 293 pounds, giving him a BMI (body mass index) of 36.6 kilograms per meter squared. A BMI of 30 or greater is considered obese [NHLBI, no date]. He saw his PCP (primary care provider) regularly to follow-up on his type 2 diabetes and was prescribed oral medication to control his blood glucose. His hemoglobin A1C (reflects blood glucose control over the past 2–3 months) was checked approximately every 3 months and showed considerable variability; in June 2016 it was 11.1% and the following September it was 7.5% (the usual A1C target for diabetics is <7% [ADA 2017]). His hypertension was well controlled with medication. The last reading by his PCP was 134/88 mm Hg (the treatment goal is generally <140/90 [James et al. 2014]). Results of lipid blood tests were not available but the FF was taking lipid-lowering medication. The FF was diagnosed with obstructive sleep apnea in 2015, for which a CPAP (continuous positive airway pressure) ventilator was prescribed to keep his airway open during sleep.

In July 2016, the FF was diagnosed with “blue toe syndrome”, a condition caused by atherosclerotic plaque material that embolizes and blocks an artery in the toe [Saric and Kronzon 2011]. A stent was placed in the toe to restore blood flow. In November 2016, the FF tripped and fell and developed arterial blood clots that caused compartment syndrome in his leg. (Compartment syndrome is dangerously elevated pressure within an enclosed sheath of muscles). He required fasciotomy surgery to relieve the elevated pressure and was off work for 3 months. The FF returned to work one week before his death. The MVA on February 8, 2017 was the first emergency the FF had responded to since his injury the preceding November.

Fire Department

At the time of the NIOSH investigation, the FD consisted of 20 uniformed personnel and 2 fire stations. It served a population of approximately 1,500 in a geographic area of 45 square miles. In 2016, the FD responded to 127 calls.

Employment and Training

Applicants must be at least 18 years of age, possess a valid state driver’s license, have a high school diploma or equivalent, and have not committed a felony. Potential members are encouraged to attend weekly meetings before applying to the department. Applicants must complete an application form and be approved by the Trustees and the Fire Association hiring committee. The new member is on probation for one year. The FF had been with the FD for 2 years but had been a volunteer in other

towns where he lived for about 10 years. The FF also worked as a trucker for a local agriculture company.

Medical Evaluation/Wellness and Fitness Programs

The FD does not require preplacement medical evaluations for applicants or for members. When applicants apply to the FD, they are required to complete a medical history form. The FD does not have a formal policy of requiring medical clearance following a serious injury or illness. The FD does not have exercise equipment available for members. It does not offer a comprehensive wellness-fitness program as recommended by the IAFF/IAFC Wellness-Fitness Initiative [IAFF and IAFC, 2008].

Discussion

Sudden Cardiac Events

Sudden cardiac death accounts for nearly half of all cardiac deaths in the United States and is the leading cause of on-duty deaths among fire fighters [Fahy et al. 2017; Myerburg and Castellanos 2015]. The majority of sudden cardiac deaths (approximately 80%) are attributable to preexisting atherosclerotic coronary artery disease [Myerburg and Castellanos 2015; Yang et al. 2013]. A substantial number of cases have underlying structural abnormalities of the heart [Steinhaus et al. 2012; Yang et al. 2013].

The narrowing of the coronary arteries by atherosclerotic plaques develops over many years, usually decades [Libby 2013]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion. A heart attack or myocardial infarction typically occurs with the sudden occlusion of a coronary artery that has not developed a collateral blood supply. This sudden blockage is usually due to a blood clot (thrombus) forming on top of a ruptured plaque [Libby 2013].

Risk factors for sudden cardiac death are similar to those for coronary artery disease [Myerburg and Castellanos 2015]. Non-modifiable risk factors include age (particularly $\geq$45 years), male sex, and family history of premature heart disease or sudden cardiac arrest. Modifiable risk factors include smoking, diabetes, hypertension (high blood pressure), unhealthy blood cholesterol levels, obesity, and physical inactivity. The FF had all of these non-modifiable and modifiable risk factors.

The FF had additional conditions associated with cardiovascular problems. Obstructive sleep apnea syndrome involves repeated breathing interruptions during sleep. The resulting hypoxemia causes frequent awakenings, sympathetic nervous system (“fight or flight”) discharge, and increased myocardial oxygen demand; other effects include blood pressure elevations, cardiac hypertrophy, ischemia, and enhanced clotting potential [Dorasamy 2007]. Sleep apnea increases the risk for arrhythmias, stroke, heart failure, and sudden death, but CPAP treatment has been shown to ameliorate some of the risk [Javaheri et al. 2017; Mansukhani et al. 2015; Wang et al. 2015]. The FF had an enlarged heart (530 grams) and LVH (left ventricular hypertrophy) diagnosed at autopsy. LVH, thickening of the heart muscle, is a common form of end-organ damage from chronic hypertension. The pressure overload causes myocardial cells to enlarge, and the heart may increase in overall size and weight (cardiomegaly) [Santos and Shah 2014]. The thickened myocardium requires more oxygen

and is more susceptible to ischemia, arrhythmias, and risk of sudden cardiac death [Haider et al. 1998; Tin et al. 2002]. Obesity can also cause LVH/cardiomegaly [Levy et al. 1988].

Heart attacks and sudden cardiac death can be triggered by heavy physical exertion, such as snow shoveling, and fire fighting activities, including alarm response (activates the sympathetic system) [Albert et al. 2000; Kales et al. 2007; Mittleman et al. 1993]. The FF had responded to an alarm for an MVA and performed cleanup operations during the hour just prior to his sudden cardiac arrest. These activities would have expended an estimated 3–5 METs (metabolic equivalents), which is considered a moderate level of exertion [Ainsworth et al. 2011].

Diagnosing an acute heart attack requires characteristic EKG changes, elevated cardiac enzymes, or identification of a coronary artery thrombus [Thygesen et al. 2012]. In this case, a coronary thrombus was not identified at autopsy to confirm a heart attack. However, the FF was found to have underlying severe atherosclerotic coronary artery disease, with 95% stenosis in two major arteries, and structural heart disease, with hypertrophy of the left ventricle and cardiomegaly.

Occupational Medical Standards for Structural Fire Fighters

To reduce the risk of sudden cardiac events or other incapacitating conditions, NFPA developed 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments.* This voluntary standard provides guidance on the components of preplacement and annual medical evaluations, as well as medical fitness for duty criteria [NFPA 2013a]. Several relevant conditions addressed by NFPA 1582 are discussed below.

Diabetes Mellitus

NFPA 1582 provides specific guidance for fire department physicians treating fire fighters with diabetes [NFPA 2013a]. 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:

- has had hemoglobin A1C measured at least four times a year (intervals of 2 to 3 months) over the last 12 months prior to evaluation if the diagnosis of diabetes has been present over 1 year. A hemoglobin A1C reading of 8% or greater shall trigger a medical evaluation to determine if a condition exists in addition to diabetes that is responsible for the hemoglobin A1C not accurately reflecting average glucose levels.
- if on oral hypoglycemic agents, has had no episodes of severe hypoglycemia (defined as requiring assistance of another person 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 regularly saw his physician to manage his type 2 diabetes. However, his A1C was not consistently below 8%, and there was no evidence that he had a cardiac stress test or underwent an occupational medical evaluation to address fitness for duty.

Obstructive Sleep Apnea

The FF was diagnosed with obstructive sleep apnea and given a CPAP ventilator for treatment. If sleep apnea is not treated, NFPA 1582 recommends duty restrictions because of the adverse impact on essential job functions [Somers et al. 2008; NFPA 2013a].

Peripheral Vascular Disease

The FF was diagnosed with a cholesterol embolus (blue toe syndrome) in 2016. According to NFPA 1582, symptomatic peripheral vascular disease can compromise a fire fighter's ability to carry out strenuous tasks safely during emergency operations, and a medical evaluation is recommended to determine duty limitations [NFPA 2013a].

Summary

Information available to the NIOSH investigator and guidance in NFPA 1582 indicate the FF should have been restricted from participation in full fire fighting duties.

Recommendations

***Recommendation #1: Ensure that all fire fighters receive an annual medical evaluation consistent with NFPA 1582,* Standard on Comprehensive Occupational Medical Program for Fire Departments.**

Discussion: The risks that fire fighters face as first responders warrant regular medical evaluations. Guidance regarding the content and frequency of these medical evaluations can be found in NFPA 1582 [NFPA 2013a]. These evaluations are performed to determine a fire fighter'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 recommendations of NFPA 1582.

The FD does not require medical evaluations but applicants must complete a medical history form. Recognizing that many departments struggle to identify adequate resources to provide comprehensive medical evaluations, fire service and medical experts developed a guide to assist PCPs and others to provide occupational exams for fire fighters. The *Healthcare Provider's Guide to Firefighter Physicals* includes a checklist of exam components for fire fighter physicals, as well as background on the physiological demands and other unique health risks that fire fighters face [IAFC 2017]. The guide can be downloaded from the International Association of Fire Chiefs' website.

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Recommendation #2: Ensure 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.

Discussion: The FD does not require medical clearance after a fire fighter experiences a serious injury or illness. The FF received care for his medical issues from private physicians, and it is not known if they were aware of his fire fighting duties or NFPA 1582 recommendations. Developing a policy for medical clearance is highly recommended.

According to NFPA 1582, the FD should require that physicians providing clearance are familiar with the physical demands of fire fighting and the risks that fire fighters encounter and should guide, direct, and advise members with regard to their health, fitness, and suitability for duty [NFPA 2013a]. The physician should review job descriptions and essential job tasks required for all FD positions to understand the physiological and psychological demands of fire fighting and the environmental conditions under which fire fighters perform, as well as the personal protective equipment they must wear during various types of emergency operations. The FD should provide relevant guidelines and job requirements to the physician determining clearance for duty. In addition to NFPA 1582, helpful information for physicians is available in the IAFC's *Healthcare Provider's Guide to Firefighter Physicals* [IAFC 2017].

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

Discussion: 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 [Aldana 2001; Stein et al. 2000]. Health promotion programs for fire fighters 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].

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 and IAFC 2008; NFPA 2015; Schneider 2010].

The FD does not have a wellness/fitness program. Resources that could assist the department to initiate wellness include the National Volunteer Fire Council's *Health and Wellness Guide for the Volunteer Fire and Emergency Services* [USFA 2009], and its *Heart-Healthy Firefighter Program* website, which offers tools to stand up a program targeting heart attack prevention [NVFC no date].

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

Discussion: NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, recommends that members engaging in emergency operations be annually evaluated and certified as

having met the physical performance requirements identified in paragraph 10.2.3 [NFPA 2013b]. This helps ensure that fire fighters are physically capable of performing the essential job tasks of structural fire fighting.

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiac and Medical Line-of-Duty Deaths (LODD) Investigations Team, located in Cincinnati, Ohio. Denise L. Smith, Ph.D., led the investigation and authored the report. Dr. Smith is Tisch Family Distinguished Professor, Professor of Health and Exercise Sciences, and Director of the First Responder Health and Safety Laboratory at Skidmore College. She is also 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, Cardiac and Medical LODD Investigations Team, during this investigation. Wendi Dick, MD, MSPH, provided medical consultation and contributed to the report. Dr. Dick is Lead for the Cardiac and Medical LODD Investigations Team in Cincinnati.

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Fire Fighter Suffers Cardiac Arrest While Driving Home From Fire Station After Responding to Motor Vehicle Accident – Illinois

Appendix A

Autopsy Findings

- Structural Heart Disease
  - Cardiomegaly
    - Heart weighed 530 grams. Predicted normal weight is 453 grams; ranges between 343 and 593 grams as a function of sex and body weight [Silver and Silver 2001].
  - Left ventricular wall - 1.5 cm (left ventricular hypertrophy)
    - Normal at autopsy is 1.07–1.39 cm (mean 1.23 cm) [Kitzman et al. 1998]
  - Right ventricular wall - 0.5 cm
    - Normal at autopsy is 0.29–0.47 cm (mean 0.38 cm) [Kitzman et al. 1998]
- Coronary artery atherosclerosis
  - Left anterior descending artery - 95% stenosis by calcified atherosclerotic plaque
  - Right coronary artery - 95% stenosis by calcified atherosclerotic plaque
  - No intracoronary thrombi
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Blood analysis negative for drugs of abuse

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