



Fire Fighter Suffers a Heart Attack at Brush Fire and Dies 8 Days Later – Vermont

Executive Summary

On April 27, 2016, a 58-year-old male paid-on-call fire fighter (FF) responded to a brush fire call. He drove the tanker to the scene and assisted with suppression operations. After approximately 10 minutes on the scene, he collapsed. Fire fighters on the scene evaluated the FF, found that he was breathing, and initiated care. While he was being treated the FF stopped breathing and became pulseless. Cardiopulmonary resuscitation (CPR) was initiated, and shocks were delivered with an automated external defibrillator (AED). An ambulance arrived on scene and the crew took over CPR and initiated advanced life support. During care rendered by the paramedics and fire fighters, the FF regained a spontaneous pulse, but he remained unresponsive while being transferred to the area medical center. At the medical center blood testing revealed elevated troponin levels consistent with a myocardial infarction (heart attack). The FF was stabilized and transported to a larger medical center, where he received a stent to the left main coronary artery. However, magnetic resonance imaging on May 2, 2016, revealed anoxic brain damage due to lack of oxygen. On May 5, 2016, the breathing tube was removed and the FF died.

The death certificate listed the cause of death as myocardial infarction due to atherosclerotic cardiovascular disease. No autopsy was performed. NIOSH concludes that the emergency response and light to medium physical exertion of supporting operations at a fire scene may have triggered the FF's heart attack.

Key Recommendations

- *Ensure that all fire fighters receive a preplacement and annual medical evaluation consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to identify fire fighters at increased risk for heart disease or other conditions.*
- *Ensure fire fighters are cleared for duty by a physician knowledgeable about the physical and psychological demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.*
- *Perform candidate and annual physical ability evaluations for all fire fighters involved in emergency operations.*
- *Phase in a mandatory comprehensive wellness and fitness program for fire fighters.*

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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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Introduction

On April 27, 2016, a 58-year-old paid-on-call, male FF suffered a heart attack and collapsed while supporting operations at a brush fire. He regained spontaneous circulation during emergency medical services treatment and was transported to a medical center where he was stabilized and then transported to a larger medical center where he received a stent to the left main coronary artery. However, the FF sustained severe brain injury and he died 8 days after his collapse. The U.S. Fire Administration notified NIOSH of this fatality on May 6, 2016. NIOSH contacted the affected fire department (FD) on May 6, 2016, and again on February 2, 2017, to gather additional information and to initiate the investigation. On February 9, 2017, a contractor for the NIOSH Fire Fighter Fatality Prevention and Investigation Program conducted an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- FFs who were working with the FF at the scene
- FF's daughter

NIOSH personnel reviewed the following documents:

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

Investigation

On April 27, 2016, a 58-year-old male paid-on-call FF responded to a brush fire at 1254 hours. The FF responded to the call as the driver of the tanker along with his Chief. The call was for an intentionally set brush fire that was out of control. The FF and his Chief arrived on scene at 1301 hours and found approximately half an acre of grass and one quarter of an acre of brush on fire. The fire ran along a fence line and was fueled by brush that had been cut and stacked along the fence line. It was a clear spring day (45°–50°F, winds out of northwest at 10 mph [FD incident report]). The FF, who had expertise in wildland fire, directed other fire fighters on where to deploy hoselines to most effectively suppress the fire.

At 1310 hours the fire was reported as under control but not fully extinguished. The Chief asked the FF to retrieve additional hose from the engine. The FF walked approximately 50 feet up a gentle slope and retrieved 50 feet of hoseline from the engine (approximately 35–40 pounds). While at the engine he

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spoke briefly to another fire fighter and was in no apparent distress. He started back down the gently sloped hill toward the fire. Moments later, the fire fighter who was at the engine heard the Chief call over the radio for a “man down.” The fire fighter from the engine ran toward the fire where the Chief was working and realized the FF had collapsed. The Chief and other fire fighters on the scene evaluated the FF and found him to be nonresponsive with difficulty breathing. The FF was provided oxygen and assisted ventilation. An ambulance was requested at 1313 hours. While receiving care the FF stopped breathing, and CPR was initiated. A fire fighter/first responder who was in his vehicle at the scene responded to the FF with an AED and his medical bag. The FF lost his pulse, and the AED revealed that a shock was advised. A shock was given, CPR was resumed until the FF was reevaluated, and another shock was administered.

An ambulance arrived on scene at 1324 hours. Paramedics evaluated the FF and found him to be pulseless and breathless with no signs of life. They applied the defibrillator pads, analyzed the rhythm, and delivered a shock. They gained intravenous and intraosseous access and administered cardiac medications. The FF was intubated with an endotracheal tube with location confirmed by visualization, condensation in the tube, and end-tidal CO₂. Paramedics provided another shock. The FF regained a spontaneous pulse and paramedics continued to provide ventilation via endotracheal tube and bag valve device during transport to the hospital.

When the FF arrived at the ED at 1412 hours, he remained unresponsive but had a spontaneous pulse of 107 beats per minute and a blood pressure of 120/65 millimeters of mercury (mmHg). ED personnel collected blood, placed a nasogastric tube and Foley catheter, and administered medications. Blood results revealed elevated troponin levels, and the electrocardiogram (ECG) revealed ST segment changes consistent with an anterolateral myocardial infarction. At the ED the FF was cooled with ice. ED staff decided to send the FF to a university-based medical center for hypothermic protocol and possible cardiac intervention. (Cooling the body may prevent damage to the brain after it goes without oxygen during cardiac arrest [Arrich et al. 2016].) At 1530 hours, an ambulance arrived to transport the FF; the FF’s blood pressure was 120/60 mmHg, his pulse was 82, and he was in normal sinus rhythm but he remained unconscious. The FF’s condition was listed as critical. He remained stable throughout transport and care was transferred to the medical center at 1610 hours.

An echocardiogram performed upon arrival at the medical center revealed a mildly dilated left ventricular cavity, severely reduced systolic function (ejection fraction of 15%–20%; normal is 50%–70% [AHA 2015]), and severe diffuse hypokinesis (weakened contraction of the heart muscle). The FF was taken to the cardiac catheterization lab where a stent was placed in the left main coronary artery. Despite establishing good blood flow to the heart, magnetic resonance imaging on May 2, 2016, found diffuse anoxic brain injury. On May 5, 2016, the FF was extubated and died at 1400 hours from respiratory failure secondary to global anoxic brain damage due to cardiac arrest.

Medical Findings

The death certificate completed by the medical examiner identified the cause of death as myocardial infarction due to atherosclerotic cardiovascular disease. Because diagnostic testing had identified the cause of death, no autopsy was performed.

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The FF had a history of hypertension, dyslipidemia, diabetes mellitus, peripheral artery disease (stenting to right iliac artery), and coronary artery disease. He had a myocardial infarction in July 2009 and was diagnosed with Type II diabetes mellitus at that time.

The FF was a smoker with no known family history of cardiovascular disease based on interview with family. Medical records indicated that he was 72 inches tall and weighed 205 pounds, giving him a body mass index of 27.8 kilograms per meter squared [CDC 2015]. At his most recent medical examination, in October 2015, the FF had a blood pressure of 108/54 mmHg (normal resting is between 90/60 and 120/80 mmHg) and testing revealed a hemoglobin A1C level of 6.7% (a level below 7% is recommended for diabetics). The last laboratory testing available in his medical records was from January 2010; these tests showed that the FF had total cholesterol of 116 mg/dL (desirable < 200 mg/dL), low density lipoprotein or “bad” cholesterol of 66 mg/dL (optimal < 100 mg/dL), triglycerides of 90 mg/dL (normal < 150 mg/dL), and high density lipoprotein or “good” cholesterol of 32 (normal \geq 40 mg/dL) [NHLBI 2005]. The FF performed an exercise stress test on February 11, 2010. The duration of the test was 7 minutes and 29 seconds, during which the FF reached a peak heart rate of 133 beats per minute, which was below the target heart rate, and a maximal work rate of 8.5 metabolic equivalents (METs). On August 4, 2014, the FF performed a stress echocardiogram and reached a maximal heart rate of 126 beats per minute, which was less than the target heart rate, and based on the duration of the test had a maximal work rate of < 7 METs. The stress echocardiogram also showed moderately depressed left ventricle global function (ejection fraction = 40%), severe hypokinesia of the apical-anteroseptal and mid-anterior regions of the left ventricle, and akinesia (no contraction) of the apical region of the left ventricle.

Fire Department

At the time of the NIOSH investigation, the volunteer FD consisted of approximately 25 uniformed personnel working out of a single fire station. It served a population of approximately 4,500 in a geographic area of 43 square miles. In 2016, the FD responded to over 140 incidents, approximately half of which were fire calls and half of which were rescue calls. The FD also provided assistance on approximately 10 emergency medical calls.

Employment and Training

To join the FD, an interested person must be at least 18 years of age (or 16 years of age if applying to the cadet program), have a valid driver’s license, be a resident of the town, and complete an application. Applicants must pass a driving background check and meet with the Chief or other officer to review expectations and standard operating guidelines. The Chief discusses the potential candidate with the other officers and approves a new member.

New members receive in-house training, must attend monthly departmental training, and are sent to a neighboring FD that sponsors a course for state certification as Fire Fighter I. Typically, the training course is structured to meet one to two nights per week for approximately 10 months, and courses usually start in the fall of the year. The FF had been with the FD for over 40 years and had also served

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as a career fire fighter in a neighboring community for 32 years before retiring in 2010. The FF also served as the Fire Warden.

Medical Evaluations and Wellness/Fitness Programs

The FD does not require medical evaluations for applicants and does not require periodic medical evaluations for members. If the FD is aware of a serious injury or illness, it requires a note from the member's primary care physician before the member can return to fire fighting duty. The FD does not have fitness equipment in the station and does not offer a wellness/fitness program.

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 factors. 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 had known coronary artery disease having suffered a previous heart attack and having stents. He also had multiple risk factors, including diabetes mellitus, smoking, hypertension, dyslipidemia, and obesity (based on medical records). He also had known peripheral vascular disease. Recent testing also revealed that he had diminished heart function, impaired work (aerobic) capacity, as well as a decline in work capacity on the basis of stress tests between 2010 and 2014.

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 elevated cardiac enzymes (troponin) and ECG changes indicative of a heart attack.

Fire Fighting and Sudden Cardiac Death

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]. Among fire fighters, 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; Kales et al. 2007; NIOSH 2007]. The FF responded to a brush fire where he supported operations for approximately 10 minutes prior to his collapse. The FF had considerable experience in wildland fire fighting (he was the Fire Warden) and he helped direct hoseline placement for suppression. Immediately before his collapse he had retrieved 50 feet of hose from the engine. NIOSH concludes that the emergency response and the physical exertion of operating on the scene may have triggered his heart attack.

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Diabetes Mellitus

NFPA 1582 provides guidance for fire department physicians when evaluating fire fighters with diabetes [NFPA 2013]. The standard states that diabetes mellitus that requires insulin compromises the member's ability to safely perform multiple essential job tasks, and a fire fighter with this condition should be restricted from duty unless the member meets all of the following criteria:

- is maintained by a physician knowledgeable in current management of diabetes mellitus
- has demonstrated over a period of at least 3 months the motivation and understanding required to closely monitor and control blood glucose levels through nutritional therapy and insulin administration
- 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 ECG and cardiac imaging)
- has a signed statement and medical records from an endocrinologist or physician knowledgeable in the current management of diabetes mellitus as well as the essential job tasks and hazards of fire fighting that the fire fighter meets the following criteria:
 - is maintained on a stable insulin regimen and has demonstrated over a period of at least 3 months the motivation and understanding required to closely monitor and control capillary blood glucose levels despite varied activity schedules through nutritional therapy and insulin administration
 - has had hemoglobin A1C measured at least four times per year at intervals of 2 to 3 months during the past 12 months 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.
 - does not have an increased risk of hypoglycemia due to alcohol use or other predisposing factors
 - has had no episodes of severe hypoglycemia in the preceding 1 year, with no more than 1 episode of severe hypoglycemia in the preceding 5 years
 - is certified not to have a medical contraindication to firefighting training and operations

The FF was an insulin-dependent diabetic who did not meet several of the above criteria for full fire fighting clearance. The FF did not meet 12 METs on cardiac stress testing, he had renal clearance less than 60 milliliters per minute (2014 record), and he did not have a dilated retinal exam. Additionally, the FF did not have documentation from an endocrinologist or physician knowledgeable in diabetes management indicating that he met the criteria regarding diabetes management and fire fighting training and operations.

Occupational Medical Standards for Structural Fire Fighters

To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire

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fighters, the National Fire Protection Association (NFPA) developed NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments* [NFPA 2013]. This voluntary industry standard includes recommendations for medical evaluations of candidates (e.g., preplacement), annual evaluations of members, and medical fitness for duty criteria. A medical evaluation based on the NFPA 1582 standard would have found that the FF had insulin-dependent diabetes mellitus, as well as a history of significant coronary artery disease, including a myocardial infarction in 2009, persistence of a modifiable risk factor for acute plaque rupture (tobacco use), lower than normal ejection fraction, and diminished functional capacity as revealed by stress echocardiography. On the basis of the duration of the stress echocardiogram, his aerobic capacity was below 8 METs [Heyward and Gibson 2014], a level at which NFPA 1582 indicates a prescribed aerobic fitness program shall be required and restriction from a number of essential job tasks shall be considered. The information available to the NIOSH investigator indicates the FF should not have been medically cleared for unrestricted fire fighting duty according to NFPA 1582 guidance.

Recommendations

Recommendation #1: Ensure that all fire fighters receive a preplacement and annual medical evaluation consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to identify fire fighters at increased risk for cardiovascular disease or other conditions.

Discussion: Medical evaluations are performed to determine a fire fighter's ability to perform duties without presenting a significant risk to the safety and health of himself/herself or others. Guidance regarding the content and frequency of these evaluations can be found in NFPA 1582 and in the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) *Fire Service Joint Labor Management Wellness/Fitness Initiative* [IAFF, IAFC 2008; NFPA 2013]. Following this recommendation will require significant resources and may be difficult to implement. Although the FD is not legally required to follow the NFPA standard or the IAFF/IAFC guideline, evaluations are highly recommended and steps should be taken to ensure each fire fighter has the physical and mental ability to safely perform duties without presenting a significant risk to the fire fighter or others. The IAFC recently developed a 4-page "*Healthcare Provider's Guide to Firefighter Physicals*" to assist community medical providers in providing recommended physical examinations and screenings for fire fighters [IAFC 2016]. Additional suggestions for overcoming the financial burden of implementing medical examinations for volunteer fire fighters can be found in the *Health and Wellness Guide for the Volunteer Fire Service* developed by the U.S. Fire Administration with significant input from the National Volunteer Fire Council. This guide addresses issues specific to volunteer fire departments and volunteer fire fighters [USFA 2009].

The FD does not require occupational medical evaluations for candidates or members. The FF received a medical examination from a private provider in the fall of 2015, but it is not known if this evaluation included all of the recommended occupational components to address his firefighting duties.

Recommendation #2: Ensure fire fighters are cleared for duty by a physician knowledgeable about the physical and mental demands of fire fighting, the personal protective equipment used by fire

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fighters, and the various components of NFPA 1582.

Discussion: According to NFPA 1582, the FD should require that physicians are familiar with the physical and mental 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 2013]. 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 FF underwent medical examination by a private provider in the fall of 2015. According to NFPA 1582, he had two medical conditions that would preclude a fire fighter from performing as a member in emergency operations because of a significant risk to the safety and health of the fire fighter or others.

Recommendation #3: Perform an annual physical ability evaluation.

Discussion: NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, requires the FD to develop physical performance requirements for candidates and fire fighters who engage in emergency operations [NFPA 2013]. Members involved in emergency operations should be annually qualified (physical ability evaluation) to meet the physical performance standards. The FD does not have physical ability performance requirements for fire fighters, but once developed, the evaluation could be accomplished as part of the FD monthly training program.

Recommendation #4: Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

Discussion: 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 USFA *Health and Wellness Guide for the Volunteer Fire and Emergency Services*, and *Fire Fighter 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 work days [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].

The FD does not have a wellness/fitness program. Given the FD's structure and budget limitations, helpful resources for starting a program may include the *Heart-Healthy Firefighter Program* developed by the National Volunteer Fire Council [NVFC no date], and the *Health and Wellness Guide for the Volunteer Fire and Emergency Services* [USFA 2009].

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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 in Cincinnati, Ohio. Denise L. Smith, PhD, led the investigation and authored 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, Cardiac and Medical LODD Investigations Team during this investigation. Wendi Dick, MD, MSPH, provided medical consultation and contributed to the report. Dr. Dick leads the Cardiac and Medical LODD Investigations Team in Cincinnati.

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