



Captain Suffers a Heart Attack at a Motor Vehicle Fire and Subsequently Dies—Nebraska

Executive Summary

On April 16, 2015, a 42-year-old male volunteer captain (the “Captain”) participated in auto extrication training. He set up the extrication tools and performed a door frame cut. The fire department was then dispatched to a motor vehicle fire. The Captain drove the tanker to the fire scene. He performed fire suppression duties. He then drove a tanker to a nearby town to refill the tanker’s water supply. He arrived back at the scene and assisted with overhaul. Then the Captain assisted getting a vehicle off the tow-along trailer. After the fire was declared under control, he remained at the scene to wash debris from the roadway. As the Captain prepared to leave the scene, he remarked to the assistant chief that he did not feel well. The Captain exited the tanker and sat on the rear bumper. He related that he was having chest pressure. The Captain then entered the on-scene ambulance. Ambulance emergency medical technicians checked the Captain’s vital signs. Feeling nauseated, the Captain stepped outside the ambulance and collapsed. He was placed back inside the ambulance. Cardiopulmonary resuscitation (CPR) and basic life support began. Air Care was requested and advanced life support was provided. The Captain was transported via ground ambulance to the hospital’s emergency department (ED). Despite CPR and advanced life support, the Captain was pronounced dead.

The death certificate and the autopsy report were completed by the Medical Examiner. The cause of death was listed as “acute myocardial infarction” due to “right coronary artery thrombosis” due to “atherosclerotic cardiovascular disease.”

Key Recommendations

- *Provide preplacement and annual medical evaluations to all fire fighters consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to identify fire fighters at increased risk for coronary heart disease (CHD)*
- *Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the components of NFPA 1582*

The following recommendations would not have prevented the Captain’s death, but NIOSH investigators include them to address general safety and health issues:

- *Provide fire fighters with medical clearance to wear a self-contained breathing apparatus (SCBA) as part of the fire department’s medical evaluation program*

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- *Perform candidate and annual physical ability evaluations*
- *Phase in a mandatory comprehensive wellness and fitness program for fire fighters*

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 16, 2015, a 44-year old volunteer captain (the “Captain”) died after suffering a fatal heart attack at a motor vehicle fire. NIOSH was notified of this fatality on April 20, 2015, by the U.S. Fire Administration. NIOSH contacted the affected fire department on April 30, 2015, to gather additional information and on July 26, 2016, to initiate the investigation. On August 22, 2016, a safety and occupational health specialist from 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
- Captain’s spouse

NIOSH personnel reviewed the following documents:

- Fire department standard operating guidelines
- Witness statements
- Police report
- Ambulance response report
- Air care response report
- Emergency department report
- Death certificate
- Autopsy report
- Primary care physician records

Investigation

On April 16, 2015, the Captain arrived at his fire station at about 1850 hours for auto extrication training. At 1917 hours, the Captain drove the tanker to the training site. He arrived at the training site at 1925 hours. Two cars had been placed in a ditch for extrication. The Captain wore full bunker gear, helmet, and gloves. He retrieved the extrication tools and placed them at a nearby tool staging area. For approximately 7 minutes, he used a scissor tool to cut into the vehicle and assisted others with extrication cuts.

At 1956 hours, the fire department was dispatched to a motor vehicle fire. The Captain drove the tanker to the scene, arriving at 2001 hours. A pickup truck (pulling a trailer with a vehicle on the trailer) was on fire. No one was trapped but the truck was full of fuel. The Captain and a crewmember operated a hoseline to control the fire at the rear of the vehicle. Then they backed up the hoseline to a

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safer distance. At 2021 hours, the Captain got a bottle of water to drink and checked on the fire apparatus at the scene. At 2030 hours, he notified the fire chief that one of the tankers was low on water. The Captain drove that tanker 5 miles to a nearby town to fill the tanker. The Captain completed the refill and returned to the scene at 2050 hours. By this time, the fire was under control. Crewmembers began overhaul. The Captain assisted in removing the vehicle on the tow trailer. At 2130 hours, some of the fire apparatus were sent back to the fire station. The Captain remained on the scene and assisted in washing debris from the street. He then climbed into the tanker.

At 2200 hours, the Captain notified the assistant chief that he did not feel well. The Captain exited the tanker and sat on the rear bumper before entering the ambulance for evaluation. The Captain complained of having chest pressure. His vital signs were taken. He had a blood pressure of 128/118 millimeters of mercury (mmHg) (normal is 120/80), a pulse rate of 126 beats per minute (normal is 60-80), and his oxygen saturation was at 68% (normal is 95-100%). The Captain became nauseated and stepped outside the ambulance. He collapsed and crewmembers placed him on a cot and into the ambulance. Dispatch was notified and Air Care was requested at 2206 hours. CPR began and oxygen was administered via bag-valve-mask. An automated external defibrillator (AED) was placed. The Captain was defibrillated 8 times.

Air Care landed on the scene at 2221 hours. Advanced life support, including an intravenous line, cardiac monitoring, and intubation, began. Tube placement was verified by capnography [AHA 2016a]. The cardiac monitor revealed asystole (no heart beat). CPR continued. The ambulance, with the Air Care crew, departed the scene at 2233 hours en route to the hospital's ED. At 2234 hours, the cardiac monitor showed sinus rhythm with a weak pulse of 120 beats per minute (sinus tachycardia). The Captain tried to start breathing. At 2238 hours the cardiac monitor showed pulseless electrical activity and CPR resumed. His heart rhythm reverted to asystole.

The ambulance arrived at the ED at 2246 hours. Inside the ED, advanced life support continued for 13 minutes more. The Captain was pronounced dead at 2259 hours by the attending physician. Resuscitation efforts were discontinued.

Medical Findings

The death certificate and the autopsy report were completed by the Medical Examiner. They listed "acute myocardial infarction" due to "right coronary artery thrombosis" due to "atherosclerotic cardiovascular disease" as the cause of death. Pertinent findings from the autopsy are listed in Appendix A.

The Captain had no diagnosed medical conditions. However, three times between 2009 and 2011 his blood pressure was elevated (152/94 millimeters of mercury [mmHg], 160/86 mmHg, and 138/100 mmHg). He was not prescribed any medications.

Fire Department

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At the time of the NIOSH investigation, the volunteer fire department consisted of two fire stations with 23 uniformed personnel. It served 7,000 residents in a geographic area of 275 square miles.

Membership and Training

New fire fighter applicants are required to have a state driver's license. They must pass a background check. The applicant must list any disability or handicap on the application. This determines whether the applicant may become an interior structural fire fighter, external support fire fighter, or a non-emergency response member. New members are on probation for 6 months. They receive in-house basic fire fighter training. The fire department offers training twice monthly. The state does not have minimum training standards. The Captain was certified as a Fire Fighter I, First Responder, and in technical rescue. He was promoted to Captain in 2012 and had 8 years of fire fighting experience.

Preplacement and Periodic Medical Evaluations/Return to Work Medical Evaluations

Preplacement and periodic medical evaluations are not required by the fire department. If a member is injured on duty, clearance for return to duty is required. The clearance is provided by the member's primary care physician, who provides the clearance to the fire chief. The fire chief makes the final determination regarding return to duty. If a member has a major illness and cannot respond to emergencies or take part in other fire department activities, the member's primary care physician must provide medical clearance for return to duty. The clearance is provided to the fire chief who makes the final decision about return to duty.

Wellness/Fitness Programs

The fire department does not have a wellness/fitness program. Candidate and annual physical ability tests are not required. The Captain exercised by riding a bicycle for about 30 minutes at least three times per week.

Discussion

Coronary Heart Disease and Sudden Cardiac Events

In the United States, atherosclerotic CHD 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 2016b; NHLBI 2016]. The Captain had one non-modifiable risk factor (male gender) and one modifiable risk factor (obesity).

Coronary artery narrowing by atherosclerotic plaques occurs over many years, typically decades [Libby 2008]. 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

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blood supply. This sudden blockage is primarily due to blood clots (thromboses) that form on top of atherosclerotic plaques. Establishing a recent (acute) heart attack requires characteristic electrocardiographic changes, elevated cardiac enzymes, or a coronary artery thrombus. In this case, an acute coronary artery thrombus was revealed at autopsy. Additional evidence of CHD revealed at autopsy included an old, healed heart attack with adjacent changes compatible with early ischemia.

Left Ventricular Hypertrophy (LVH)

On autopsy, the Captain was found to have LVH, which increases the risk for sudden cardiac death [Levy et al. 1990]. 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]. Although the Captain had three instances of elevated blood pressure readings, he was not diagnosed with hypertension. He did not have heart valve problems. The autopsy did reveal early ischemia from the old heart attack. Therefore, his LVH was probably the result of ischemia. Whether undiagnosed hypertension was present and contributed to his death is uncertain.

Physiological Stress of Firefighting

Heart attacks and sudden cardiac death can be triggered by heavy physical exertion [Mittleman et al. 1993; Willich et al. 1993; Albert et al. 2000]. Among fire fighters, sudden cardiac events have been associated with/triggered by alarm response, fire suppression, and heavy exertion during training (including physical fitness training) [Kales et al. 2003, 2007; NIOSH 2007]. The Captain performed auto extrication training then responded to a vehicle fire where he assisted with fire suppression and cleanup while wearing full bunker gear. These activities expended about 9 metabolic equivalents, which is considered heavy physical activity [Ainsworth et al. 2011].

Occupational Medical Standards for Structural Fire Fighters

To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the National Fire Protection Association developed NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments* [NFPA 2013a]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation and medical fitness for duty criteria.

Recommendations

Recommendation #1: Provide preplacement and annual medical evaluations to all fire fighters in accordance with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to identify fire fighters at increased risk for CHD.

Discussion: Guidance regarding the content and frequency of these medical 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 2013a]. These evaluations are performed to determine fire fighters' medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. Following this recommendation will require significant resources and may be difficult to implement. In

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addition, the fire department has no legal obligation to follow the NFPA standard or the IAFF/IAFC guideline.

Recommendation #2: Ensure that fire fighters are cleared for return to 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: NFPA 1582 requires that the fire department designate a physician responsible for guiding, directing, and advising the 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 fire department positions to understand the physiological and psychological demands of fire fighters and the environmental conditions under which they must perform, as well as the personal protective equipment they must wear during various types of emergency operations. Currently, the member's primary care physician provides medical clearance for return to work. It is unclear if fire fighters' personal physicians are familiar with the recommendations of NFPA 1582 [NFPA 2013a].

The following recommendations would not have prevented the Captain's death, but NIOSH investigators include them to address general safety and health issues:

Recommendation #3: Provide fire fighters with medical clearance to wear SCBA as part of the fire department's medical evaluation program.

Discussion: The Occupational Safety and Health Administration (OSHA) *Revised Respiratory Protection Standard* requires employers to provide medical evaluations and clearance for employees using respiratory protection [29 CFR 1910.134]. These clearance evaluations are required for private industry employees and only for public employees in states operating OSHA-approved state plans. Because Nebraska does not operate a state OSHA plan [OSHA 2016], the fire department is not required to provide medical evaluations for employees using respirators. However, we recommend voluntary compliance with this recommendation to improve fire fighter health and safety.

Recommendation #4: Perform candidate and annual physical ability evaluations.

Discussion: NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires the fire department to develop physical performance requirements for candidates and members who engage in emergency operations [NFPA 2013b]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2013b]. Once developed by the fire department, the annual evaluation could be performed as part of the annual training program.

Recommendation #5: 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 the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, the National Volunteer Fire Council Health and

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Wellness Guide, in Firefighter Fitness: A Health and Wellness Guide, and in NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, [IAFF, IAFC 2008; USFA 2009; Schneider 2010; NFPA 2015]. 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 [Pelletier 2009; Baicker et al. 2010]. Fire service health promotion programs have been shown to reduce coronary artery disease risk factors and improve fitness levels, with mandatory programs showing the most benefit [Dempsey et al. 2002; Womack et al. 2005; Blevins et al. 2006; Poston et al. 2013]. A study conducted by the Oregon Health and Science University reported a savings of more than \$1 million for each of four large fire departments implementing the IAFF/IAFC wellness/fitness program compared to four large fire departments not implementing a program. These savings were primarily due to a reduction of occupational injury/illness claims with additional savings expected from reduced future nonoccupational healthcare costs [Kuehl et al. 2013].

The fire department does not offer a wellness/fitness program and exercise equipment is not available in the fire stations. Given the fire department's structure, the National Volunteer Fire Council program would be applicable [USFA 2009]. NIOSH would recommend a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program.

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component in Cincinnati, Ohio. Mr. Tommy Baldwin (MS) led the investigation and co-authored the report. Mr. Baldwin is a Safety and Occupational Health Specialist, a National Association of Fire Investigators (NAFI) Certified Fire and Explosion Investigator, an International Fire Service Accreditation Congress (IFSAC) Certified Fire Officer I, and a former Fire Chief and Emergency Medical Technician.

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Appendix A Autopsy Findings

- Coronary artery disease
 - Total (100%) occlusion of the right coronary artery by a thrombus (blood clot)
 - Moderate (50%) focal narrowing of the left anterior descending coronary artery
- Hypertensive heart disease
 - Cardiomegaly (heart weighed 480 grams [g])
 - predicted normal weight based on body length ranges between 330 g and 410 g [Zeek 1942]
 - Predicted normal weight as a function of sex, age, and body weight is 421 g (ranges between 319 g and 556 g) [Silver and Silver 2001]
 - Left Ventricular Hypertrophy
 - Left ventricle and septum thickened (1.6 centimeters [cm] and 1.5 cm respectively)
 - 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]
 - Region of scarring in the posterior left ventricle, with areas of adjacent mottling consistent with a remote (old) myocardial infarction of the posterior left ventricle
 - Microscopic area of cardiac myocytes are slightly thin and wavy with increased eosinophilia
- Cardiac valves were normal
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Blood tests for drugs and alcohol were negative.

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