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Death in the line of duty...

National Institute for Occupational Safety and Health NIOSH

A report from the NIOSH Fire Fighter Fatality Investigation and Prevention Program December 16, 2019

46-Year-Old Airport Firefighter Suffers Fatal Heart Attack Responding to Call—Pennsylvania

Executive Summary

On March 20, 2019, at approximately 0058 hours, a 46-year-old career firefighter (FF) failed to respond to the apparatus for a call. A fellow firefighter went to find the FF and discovered him unconscious on the floor in a hallway leading to the apparatus bay. Crew members initiated cardiopulmonary resuscitation (CPR) and notified in-house paramedics, who provided advanced cardiac life support (ACLS) and transported the FF. The emergency department (ED) staff continued resuscitation efforts for nearly 20 minutes. The FF never regained an organized cardiac rhythm and was pronounced dead at 0151 hours.

The Medical Examiner's report listed the cause of death as "acute myocardial infarction due to hypertensive and atherosclerotic cardiovascular disease." The autopsy found a large portion of the left ventricle wall was damaged due to a heart attack (myocardial infarction). There was severe atherosclerotic plaque in several of the major coronary arteries and evidence of prior stenting in the descending aorta. National Institute for Occupational Safety and Health (NIOSH) investigators concluded that the sympathetic nervous system activation associated with the alarm response likely triggered a heart attack in an individual with underlying cardiovascular disease.

Key Recommendations

NIOSH offers the following recommendations to reduce the likelihood of heart attacks and sudden cardiac arrest among firefighters at this and other fire departments across the country.

- *Ensure firefighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment (PPE) and self-contained breathing apparatus (SCBA) used by firefighters, and the various components of National Fire Protection Association (NFPA) 1582.*
- *Develop a tracking system that ensures that firefighters who require follow-up by another provider receive the follow-up, and that results are reviewed by the physician providing medical clearance or return to duty.*
- *Adopt a mandatory comprehensive wellness and fitness program for firefighters.*

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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 March 20, 2019, a 46-year-old career firefighter (FF) suffered a fatal heart attack while responding to the apparatus for a rescue call at the airport. The U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this fatality on March 21, 2019. On July 23, 2019, a contractor for the NIOSH Fire Fighter Fatality Investigation and Prevention Program (the NIOSH investigator) conducted an on-site investigation of the incident.

During the investigation, the NIOSH investigator interviewed the following people:

- *Fire Commissioner*
- *Deputy Chief of Health and Safety*
- *Deputy Chief of Incident Safety*
- *Fire Marshal*
- *Union President*
- *Captain in Charge of Shift*
- *Medical Director for City*

The NIOSH investigator reviewed the following documents:

- *Fire department (FD) incident reports for calls throughout the shift*
- *Emergency medical service (EMS) (ambulance) report*
- *Hospital emergency department (ED) records*
- *Occupational medical records*
- *Death certificate*
- *Autopsy report*

Investigation

On March 19, 2019, at 0800 hours the 46-year old FF attended roll call for the day shift (12 hour) at his airport fire station as part of a mutual exchange of tour. The FF continued on his regularly scheduled night shift beginning at 2000 hours. The airport fire station was staffed with two captains (one of whom was filling a shift for a lieutenant), 12 firefighters, and 2 paramedics. The FF was part of a four-member engine crew and was assigned as the driver. At 1146 hours, the FF and his crew were

dispatched on a call for an aircraft that may have difficulty landing, but the aircraft made a normal landing and no members dismounted their apparatus.

On the evening of March 19, the FF prepared dinner for crew members at the station, and then most members watched a basketball game. It is reported that the FF was in a good mood and his captain (CAPT) was not aware of the FF having any issues.

On March 20, at 0042 hours, the engine crew was dispatched to the airport for a person stuck in an elevator. The call was canceled when the crew was notified that everyone was out of the elevator. The crew returned to the station and the CAPT and the FF spoke briefly before the CAPT returned to his office/bunkroom. There was no indication that the FF was experiencing any symptoms or any distress. At 0058 hours, the engine was dispatched again for a person stuck in an elevator. The crew responded to the apparatus but the FF failed to respond. The CAPT sent another member to find the missing FF. The FF was found unconscious and not breathing in a hallway leading to the apparatus bay. The member notified the shift commander that there was a FF down, and the shift commander notified the watchman to activate the in-house alarm and announce a code blue.

The member who went to look for the FF found him in the left side prone position and rolled him over on his back. The FF was not breathing, he had no pulse, and his skin was purple. After the member called for help, he opened the airway and began cardiopulmonary resuscitation (CPR). Other members arrived very shortly. At 0108 hours, dispatch announced a code blue over the public announcement (PA) system, and paramedics and firefighters responded to provide care. The FF was attached to a cardiac monitor that showed the was in asystole. High-flow oxygen was provided with a non-rebreather mask and oral airway. Oral intubation was unsuccessful due to a difficult airway and a King Airway™ was placed (positive for bilateral breath sounds, confirmed with capnography). The FF received 5 rounds of epinephrine with no change in his status. The FF had one brief electrocardiogram (EKG) change (approximately one minute) where he had a pulseless electrical rhythm, otherwise he remained in asystole throughout treatment. The ambulance departed the scene at 0122 hours and arrived at the ED at 0133 hours with advanced cardiac care continued en route. Advanced cardiac life support (ACLS) protocols were continued in the ED but to no avail. At 0151 hours the FF was pronounced dead.

Medical Findings

The FF made no complaints of chest pain, dizziness, or fatigue after he completed a call just 10 minutes before his collapse. However, based on contemporaneous notes taken after his death, he had complained of symptoms of indigestion in the week before the event and was scheduled to see his personal physician that day. The Medical Examiner's report identified the cause of death as acute myocardial infarction due to hypertensive and atherosclerotic cardiovascular disease. The heart attack damaged the inferior wall of the left ventricle (4.0 centimeter [cm] x 4.8 cm area of softened myocardium). There was severe atherosclerosis noted in the left main, left anterior descending, left circumflex, and right coronary arteries. The autopsy also noted a plastic graft in the abdominal aorta between the renal arteries and iliac arteries. **See Appendix A for a more detailed description of autopsy findings.**

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The FD and local union have recently begun providing medical evaluations for firefighters through a joint labor-management agreement. Through this arrangement, incumbent firefighters receive medical evaluations offered through a Contract Provider every other year. The medical evaluations are performed at the fire academy, scheduled by the local union, and paid for by the City. FFs who are not cleared for duty through this process are referred to their primary care provider (PCP) or a specialist to have their condition evaluated further and/or treated. To be cleared for duty, the FFs must bring medical records and recommendations from their PCP or specialist to the city medical evaluation unit, which makes final determination on clearance for duty and return to duty.

The FF received a medical evaluation for the FD through the Contract Provider on October 23, 2018. At that medical exam, he had elevated blood pressure; 160/102 millimeters of mercury (mmHg) for the first reading and 170/102 mmHg for a repeat measurement (normal is < 120/80; hypertension is considered ≥ 130 systolic and/or ≥ 80 diastolic) [Whelton et al. 2017]. The FF told the Contract Provider that he had not taken his blood pressure medication that morning. The FF's EKG was normal. His pulmonary function testing suggested reduced lung function (functional vital capacity [FVC] 78% of age-predicted value). Blood work performed as part of the evaluation indicated the FF had:

- high total cholesterol (215 mg/dL; desirable < 200)
- high "bad" low-density lipoprotein (LDL) cholesterol (119; optimal < 100)
- high triglycerides (336 mg/dL; normal < 150)
- low level of "good" high-density lipoprotein (HDL) cholesterol (29; normal > 40)
- high blood sugar and elevated hemoglobin A1C diabetes screening tests (blood glucose = 128 mg/dL and normal is < 100; A1C = 6.1% and normal is 4.0%–5.6%) [Mayo Clinic 2019].

Based on the findings of the medical evaluation, the Contract Provider did not perform the exercise stress test (EST) that is typically performed as part of the medical evaluation and did not clear the FF for duty. The FF was instructed to provide documentation that his blood pressure was controlled. The FF was also counseled to quit smoking, lose weight, and lower his hemoglobin A1C.

On October 24, 2018, the FF visited the physician at the city medical evaluation unit after taking his blood pressure medication. At that evaluation his blood pressure was 140/90 mmHg and the FF was cleared for duty. Because the FF did not have an EST during his periodic FD medical evaluation, he was instructed to get an EST (with imaging) through his PCP, and then return to the city's medical evaluation unit. He had a follow-up appointment scheduled for December 6, 2018, but did not show up for the appointment due to possible miscommunication or misunderstanding. There are no records available to NIOSH to indicate that he ever had the EST.

The FF was 66 inches tall and weighed 164 pounds giving him a body mass index (BMI) of 26.5 (a BMI of 25–29.9 is considered overweight, but not obese) [NHLBI no date-a]. He was a smoker. Based on his age and modifiable risk factors, and not including diabetes as a risk despite his elevated hemoglobin A1C, the American Cardiology Association (ACC) Heart Risk calculator estimated that the FF had a 20.6% 10-year risk of heart attack or stroke (0.7% risk with optimal modifiable risk factors).

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Fire Department

At the time of the NIOSH investigation, the FD consisted of approximately 2,600 uniformed personnel operating out of 63 fire stations. It serves a population of approximately 1,500,000 in a geographic area of about 140 square miles.

Employment and Training

Applicants must be at least 18 years of age, have a high school diploma or equivalent, and possess a valid driver's license. Applicants take a written aptitude (civil service) exam and are ranked based on their score and priority points. Successful applicants are then offered conditional employment and must pass a criminal background check and a medical evaluation before they are hired. The FF had been with the FD for 22 years.

Preplacement, Periodic, and Return to Work Medical Evaluations

The FD requires preplacement medical evaluations for applicants. Components of the medical evaluation include the following:

- *Complete medical history*
- *EKG*
- *Complete blood count*
- *Urinalysis*
- *Urine drug screen*
- *Audiogram*
- *Vision test*
- *Respirator use questionnaire*
- *Spirometry (pulmonary function testing)*
- *EST*
- *Chest x-ray.*

The FD and the local FF Union have collaborated to begin offering periodic medical evaluations to firefighters. The medical evaluation is provided by a Contract Provider and is based on the National Fire Protection Association (NFPA) 1582 Standard. Firefighters over 45 years of age have an EST as part of this evaluation. If firefighters are not cleared for duty or are cleared for restricted duty based on the periodic medical evaluation, they must follow up with their PCP to address the issue and then be cleared for duty by the city's medical evaluation unit. Firefighters must also be medically cleared by the city medical evaluation unit to return to work following a serious injury or illness.

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Wellness/Fitness Programs

The Fire Department and the Union offer wellness programming through a health plan. There is exercise equipment in fire stations and the Union offers fitness programming for members, but the FD does not require that firefighters engage in a fitness program.

Discussion

Sudden Cardiac Events

Sudden cardiac events are most often caused by heart attack or cardiac arrest (fatal arrhythmias). In the United States, atherosclerotic coronary heart disease (coronary artery disease) is the most common risk factor for cardiac arrest and sudden cardiac death [Myerburg and Castellanos 2008]. Risk for the development of atherosclerosis is grouped into non-modifiable and modifiable risk factors. Non-modifiable risk factors include age older than 45 (age > 55 for women), male sex, and family history of coronary artery disease. Modifiable risk factors include diabetes, smoking, high blood pressure (hypertension), unhealthy blood cholesterol levels, and obesity/physical inactivity [AHA 2016; NHLBI no date-b]. The FF had 3 non-modifiable risk factors (male sex, over 45 years of age, and family history). The FF had 4 known modifiable risk factors (hypertension, which was being treated; smoking; high cholesterol; and elevated blood sugar). A structurally enlarged heart (cardiomegaly or left ventricle hypertrophy) is also common among many individuals who die of sudden cardiac events [Tavora et al. 2012]. High blood pressure is one of the main contributors to an enlarged heart.

Coronary Artery Disease

Coronary artery disease refers to atherosclerotic plaque in the coronary arteries and the complications of the plaque. 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. Plaque buildup that restricts blood flow and prevents sufficient oxygen delivery to the heart muscle (myocardium) causes ischemia and often produces chest pain (angina), particularly with exertion. Heart attacks 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 a ruptured atherosclerotic plaque [Libby 2013].

Heart attacks and sudden cardiac death can be triggered by heavy physical exertion including snow shoveling and firefighting activity, including an alarm response and training [Albert et al. 2000; Franklin et al. 2001; Kales et al. 2003, 2007; Mittleman et al. 1993; NIOSH 2007; Smith et al. 2019; Willich et al. 1993]. The triggering of a heart attack by physical exertion is far more likely in individuals who do not regularly engage in strenuous physical activity [Mittleman et al. 1993].

Establishing the occurrence of an acute heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes, coronary artery thrombus/plaque rupture, or evidence of heart muscle (myocardial) damage at autopsy. In this case, the FF had evidence of a large area (4.0 cm x 4.8 cm) of damaged tissue in the left ventricle. The autopsy also identified marked atherosclerosis of the coronary arteries.

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Occupational Medical Standards for Structural Firefighters

Nearly half of all firefighter duty-related deaths are caused by sudden cardiac death. Firefighting results in multiple cardiovascular changes that could lead to plaque rupture or induce arrhythmias in individuals with underlying cardiovascular disease [Smith et al. 2016]. Research suggests that the vast majority of firefighter duty-related sudden cardiac deaths have underlying atherosclerosis, cardiomegaly/left ventricle hypertrophy, or both [Geibe et al. 2008; Kales et al. 2003; Smith et al. 2018; Yang et al. 2013]. In fact, a study that relied on firefighter autopsy data and was able to verify the presence of atherosclerosis (coronary heart disease) and structural heart changes (specifically cardiomegaly and left ventricle hypertrophy) found that more than 80% of cardiac fatalities had both types of heart disease [Smith et al. 2018].

To reduce the risk of sudden cardiac events or other incapacitating conditions among firefighters, the NFPA developed 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments* [NFPA 2018]. Regarding cardiovascular disease (CVD) screening for asymptomatic firefighters, NFPA 1582 recommends basing the decision for exercise stress testing on the firefighter's 10-year Heart Risk score (which is based on age, blood pressure, cholesterol, and other cardiovascular risk factors) [ACC/AHA 2018; NFPA 2018]. Heart Risk should be calculated each year beginning at age 40, and firefighters whose risk is 10% to < 20% should receive a symptom-limiting EST (with or without imaging) to at least 12 metabolic equivalents (METs) [NFPA 2018].

The FF had a 10-year risk score of 20.6% at his occupational medical evaluation in October of 2018. Based on his elevated blood pressure at the time of the evaluation, he did not receive an EST. The FF went to see the physician at the city's medical evaluation unit the following day after taking his prescribed blood pressure medication and his blood pressure was 140/90 mmHg. Based on this finding, the physician cleared the FF for duty and required that he follow up with his PCP to manage his blood pressure and obtain an EST because he had not received it as part of his occupational medical exam. The FF was scheduled to return to the city medical evaluation unit to evaluate his follow-up testing on December 6, 2018, but the FF did not show up for this evaluation due to possible miscommunication or misunderstanding. There are no records available to NIOSH that the FF performed the required stress test.

NIOSH offers the following recommendations to reduce the likelihood of heart attacks and sudden cardiac arrest among firefighters at this and other fire departments across the country.

Recommendations

Recommendation #1: Ensure firefighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment (PPE) and self-contained breathing apparatus (SCBA) used by firefighters, and the various components of NFPA 1582.

Discussion: According to NFPA 1582, the FD should require that physicians are familiar with the physical demands of firefighting and the risks that firefighters encounter and should guide, direct, and advise members with regard to their health, physical fitness, and suitability for duty [NFPA 2018]. The physician should review job descriptions and essential job tasks required for all FD positions to understand the physiological and psychological demands of firefighting and the environmental

conditions under which firefighters perform, as well as the PPE/SCBA they must wear during various types of emergency operations.

Recommendation #2: Develop a tracking system that ensures that FF who require follow-up by another provider receive the follow-up and that results are reviewed by the physician providing medical clearance or return to work.

Discussion: Occupational medical evaluations are intended to identify individuals who cannot perform the essential job tasks of firefighting without undue risk of sudden incapacitation. Occupational evaluations often identify conditions that require additional testing or follow-up with a personal physician/PCP. It is critical that any issues that are identified receive the required follow up, and that this information is relayed to the physician providing clearance. Clear policies and procedures must be in place to track firefighters through this entire system.

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

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* [NFPA 2015], and the IAFF/IAFC *Fire Service Joint Labor Management Wellness-Fitness Initiative* [IAFF, IAFC 2018]. 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 tailored for firefighters 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].

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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 Professor of Health and Human Physiological Sciences, and Director of the First Responder Health and Safety Laboratory at Skidmore College, where she holds the Tisch Family Distinguished Professorship. 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 Medical Officer for the Cardiac and Medical LODD Investigations Team in Cincinnati.

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Appendix A
Autopsy Findings

Coronary arteries

- Atherosclerotic stenosis in coronary arteries:
  - Left main – 95%
  - Left anterior descending – 95%
  - Left circumflex – 90%
  - Right coronary artery – 95%
- No recent thrombus
- 4.8 cm x 4.0 cm area of mottled and slightly softened myocardium within inferior wall of left ventricle

Structural

- Heart weight = 330 grams
- Left ventricle wall = 1.3 cm thick
- Right ventricle wall = 0.2 cm thick

Other Significant Cardiovascular Findings

- Marked atherosclerosis in aorta
- Plastic graft in descending aorta distal to renal arteries

Toxicology

- Negative for drugs of abuse

Author's Discussion:

Left ventricle thickness of 1.3 cm is normal on the basis of postmortem studies by Kitzman et al. [1988] (normal range 1.07 cm–1.39 cm, average 1.23 cm).

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