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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 November 1, 2022

34-Year-Old Assistant Fire Chief Suffers Heart Attack At a Motor Vehicle Accident Scene—Maryland

Executive Summary

On September 1, 2018, a 34-year-old male volunteer Assistant Chief (AC) had a heart attack after performing a difficult extrication at the scene of a motor vehicle accident. Just as the AC finished the extrication and was about to enter an air-conditioned vehicle and rehydrate, he began experiencing chest pain and nausea. An ambulance that had been dispatched to the accident scene was redirected to care for the AC. An electrocardiogram (ECG) revealed the AC was having a myocardial infarction (heart attack). The AC went into cardiac arrest en route to the hospital emergency department (ED). The AC was taken emergently to the catheterizaiton laboratory but he did not survive.

The Medical Examiner's report listed the cause of death as acute cardiac arrest with hypertensive atherosclerotic cardiovascular disease. Diabetes mellitus was listed as a contributing factor. The autopsy report noted anatomical changes consistent with chronic hypertension (heart weight was greater than predicted for age and gender and thickening of the left ventricle wall). Evidence of chronic atherosclerosis was evident with 75% narrowing of several coronary arteries. The heart also showed evidence of previous myocardial damage. The National Institute for Occupational Safety and Health (NIOSH) investigators concluded that the strenuous rescue work triggered a myocardial infarction in an individual with severe underlying atherosclerotic and hypertensive heart disease.

Key Recommendations

NIOSH offers the following recommendations to help reduce the risk of sudden cardiac events among firefighters at this and other fire departments across the country.

- *Ensure that all firefighters receive an annual medical evaluation consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.*
- *Ensure firefighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by firefighters, and the various components of NFPA 1582.*
- *Consider incident scene rehabilitation (rehab) during rescue operations as dictated by weather conditions and the work performed.*
- *Phase in a comprehensive wellness and fitness program for firefighters.*

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For further information, visit the program website at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).

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Introduction

On September 1, 2018, a 34-year-old male assistant chief (AC) had a heart attack while working at a multiple vehicle accident scene and went into cardiac arrest while being transported to the hospital. The U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this fatality on September 3, 2018. NIOSH contacted the affected fire department (FD) on August 12, 2019, to gather information and to initiate the investigation. On August 17, 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 Chief*
- *Public Information officer*
- *Firefighters who worked with the AC*

The NIOSH investigator reviewed the following documents:

- *FD incident reports for motor vehicle accident*
- *Emergency medical services (EMS) (ambulance) report*
- *Hospital ED records*
- *Autopsy report*

Investigation

The AC had been a member of this FD for 15 years and was the AC for the last year. On September 1, 2018, at approximately 1345 hours the FD was alerted to a major motor vehicle accident. At about 1400 hours, the 34-year-old AC responded as the officer of the rescue squad and arrived on the scene just a couple of minutes after the Chief arrived (1357 hours). The accident involved a head-on collision of two sport utility vehicles (SUVs), both of which were carrying 4 people. One of the SUVs had rolled onto its side, caught fire, and was resting within 12 inches of a guardrail. Prior to the arrival of the FD, bystanders had suppressed the fire and had removed three passengers from the vehicle but were unable to extricate the driver. The Chief took charge of patient triage and assigned the AC to extricate the trapped driver. The four occupants of the other SUV had sustained serious injuries but had exited the vehicle on their own before the Chief and AC arrived. They were subsequently transported by ground ambulances at the scene. The Chief assumed the task of obtaining additional resources including ambulances and a medical flight helipcopter to transport the 4 seriously injured occupants of the rolled SUV.

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The AC initially worked on the extrication of the SUV driver with one member of his rescue squad while the 3rd member of the rescue squad, a firefighter (FF)/emergency medical technician (EMT), handled the driver's initial medical care (i.e., cervical spine stabilization, airway patency, etc.). The AC gained access to the vehicle and found that the crushed vehicle had entrapped the driver by his legs and feet. The AC assigned the FF working with him to get the tools needed to cut and roll away the dashboard (dash roll) which would be necessary in order to remove the driver. While the tools were being retrieved, the AC assisted the FF/EMT in providing medical care to the driver. The extrication was complex and prolonged due to the vehicle resting on its side and within a foot of a guardrail that made it difficult to access with the extrication tools.

An engine arrived on scene about 10 minutes after the AC's rescue squad, and its crew was assigned to assist with the extrication. A second engine from a neighboring town arrived on-scene several minutes later and that crew was also assigned to assist with the extrication. An advanced life support (ALS) ambulance arrived on scene later in the incident and that paramedic was assigned to assist with patient care. In total, seven members worked to rescue the driver from the vehicle and provide patient care. The AC removed his bunker coat and used it to shield the patient as other rescuers broke the windshield, removed the roof of the vehicle, and worked on the extrication. The extrication took approximately 35 minutes and once the driver was freed from the vehicle, he was loaded onto a helicopter for transport to a trauma center.

The environmental conditions during the extrication were overcast with ambient temperature of 83°F, humidity of 74%, and a calculated heat index of 90°F [Weather Underground no date]. Responders commented on the severity of the heat as they worked on the blacktop. Fire department personnel were bringing water to the extrication team and encouraged them to take rotating breaks as the extrication effort continued but they declined to do so and never left the driver. After the extrication was completed, the Chief ordered all members working the extrication to remove their bunker gear, get into an air-conditioned utility vehicle, and rehydrate. The AC and the FF from the rescue squad walked a short distance to the utility vehicle. The FF got into the front seat and turned around to see why the AC had not closed the back door when he got into the vehicle. The FF saw the AC leaning back and holding his chest. The FF immediately ran to the Chief, indicated that the AC needed immediate medical assistance, and then ran to alert an on-scene paramedic. The paramedic instructed the driver of one of the additional ALS units on scene to reposition the vehicle so they could exit the accidence scene as soon as AC was on board.

The paramedic then ran to assess the AC, making initial contact at 1440 hours (approximately 40 minutes after AC had arrived on scene). He found the AC in obvious distress. The AC was vomiting and complaining of chest pain (rated as 10/10) radiating to the left arm. The 12 lead ECG revealed a heart attack (specifically an ST segment elevated myocardial infarction [STEMI]). The AC was alert and oriented and he was loaded into the ambulance. At 1446 hours, heart rate (HR) was 112 beats per minute and respiratory rate (RR) was 28 breaths per minute. Aspirin and nitroglycerin were provided per protocol. The ambulance left the scene at 1453 hours. Blood pressure was obtained at 1455 hours and was 139/70 millimeters of mercury (mmHg). At about 1458 hours, the AC developed ventricular tachycardia. A pulse check revealed he no longer had a pulse and a shock was given. Supplemental oxygen was also provided; 15 liters per minute (lpm) by bag-valve mask. The AC was defibrillated

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4 more times over the next 8 minutes. As they neared the ED, the AC's cardiac rhythm degraded into asystole. Manual cardiopulmonary resuscitation (CPR) was performed for about 2 minutes until the ambulance arrived at the ED. On arrival (1505 hours) to the ED, the AC was placed on a LUCAS® devise to provide external mechanical compressions and was intubated. The AC was taken to the cardiac catheterization laboratory (cath lab), where the left anterior descending artery was found to be completely occluded. During his in-hospital resuscitation, the AC was defibrillated six times and received nine rounds of epinephrine and one dose of amiodarone. In the cath lab his aortic pressure was no greater than 30 mmHg. A left ventriculography showed no evidence of ventricular activity. At 1604 hours the resuscitation efforts were ended and the AC was pronounced dead.

Medical Findings

The medical examiner identified the cause of death as hypertensive atherosclerotic cardiovascular disease as the cause of death with diabetes mellitus as a contributing factor. The heart had been procured for tissue donation, and was examined post tissue donation and a separate cardiac pathology report was obtained. The heart weight was 521 grams was within normal range of 327–570 grams but exceeded the predicted value of 427 grams for his age and gender. The was also evidence of left ventricular hypertrophy with a ventricular wall thickness of 1.5 centimeters (cm) (exceeded normal thickness limit of 1.2 cm) [Silver and Silver 2001; Smith et al. 2018]. The myocardium had focal areas of acute hemorrhage in the left ventricle. There was 75% narrowing of the the left anterior descending and right coronary arteries. There was no blood clot found in the coronary arteries.

Hospital records from his emergency department care indicate that the AC had diabetes mellitus (type not specified in records), hypertension, hypercholesterolemia, and obstructive sleep apnea. FD members reported that they believe the AC had been evaluated for chest pain within a month of the event but NIOSH did not find any records showing he had been seen by a healthcare provider.

The AC was a non-smoker. He did not exercise regularly. He was approximately 72 inches tall and weighed 267 pounds, giving him a body mass index (BMI) of 36.2 kilograms per meter squared (kg/m^2). As per the Centers for Disease Control and Prevention (CDC), a BMI between 25.0–29.9 is considered overweight and a BMI over 30 kg/m^2 is considered to be obese [CDC 2020].

Fire Department

At the time of the NIOSH investigation, the volunteer fire department consisted of 1 fire station staffed by approximately 50 uniformed personnel. The FD served a population of approximately 5,000 in a 75 square mile area.

Membership and Training

Applicants who wish to join the FD must be at least 16 years old. Applicants submit an application, are interviewed by a membership committee, must pass a criminal background check, and are then voted on by the membership. New members serve a 6 months probationary period before becoming full members.

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Medical Evaluations/Wellness/Fitness Programs

The FD does not require preplacement medical evaluations for applicants or offer periodic evaluations for members. A respiratory fit test is performed every three years. Members must provide a medical clearance from a personal physician following a serious injury or illness. The FD does not offer a wellness/fitness program.

Discussion

Sudden Cardiac Events

Sudden cardiac events are most often caused by myocardial infarction (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, male sex, and family history of coronary artery disease. Modifiable risk factors include diabetes mellitus, smoking, high blood pressure (hypertension), unhealthy blood cholesterol levels, and obesity/physical inactivity [AHA 2016; NHLBI no-date]. The FF had one known non-modifiable risk factors (male sex; it was unknown if he had a positive family history) and several known modifiable risk factor (diabetes mellitus, hypertension, hypercholesterolemia, and obesity, and he was a former smoker).

Hypertensive Heart Disease

Interactions between genetic factors and hemodynamic factors cause hypertensive heart disease in individuals with arterial hypertension [Diamond and Phillips 2005]. Hypertensive heart disease includes anatomical and functional changes to the heart and vessels as a consequence of long-standing hypertension. Left ventricular hypertrophy (LVH), due to myocyte enlargement with or without fibrosis, is a reflection of hypertensive end-organ damage, which can lead to increased ventricular mass, abnormal perfusion, congestive heart failure, and arrhythmias [Prisant 2005]. Increased heart mass predisposes to fatal arrhythmias [Kahan and Bergfeldt 2007; Tavora et al. 2012].

In addition to chronic hypertension, LVH can also be caused by a heart valve problem, obesity, or cardiac ischemia (reduced blood and oxygen supply to the heart muscle often due to coronary artery disease) [Siegel 1997; Tavora et al. 2012]. LVH is also associated with sleep apnea [Smith et al. 2018]. The autopsy showed cardiomegaly and LVH.

Diabetes Mellitus

Diabetes is associated with an increased risk of cardiovascular disease and can lead to sudden incapacitation due to either low blood glucose values or high blood glucose values. NFPA 1582 provides guidance for fire department physicians when treating firefighters with diabetes [NFPA 2018]. The AC was diabetic but he did not have an occupational medical exam so it is unclear if his diabletes was managed in a way that is consistent with NFPA 1582 guidelines.

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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 high heart rates, increased cardiac work and enhanced clotting potential and can trigger a cardiac event in individuals with underlying cardiovascular disease [Smith et al. 2016]. Research relying on autopsy data found that 80% of firefighter duty-related sudden cardiac deaths have evidence of both atherosclerosis and an enlarged heart [Smith et al. 2018] and this is also true for young (< 45 years) firefighters [Yang et al. 2013]. 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].

Incident Scene Rehabilitation

Incident-Scene Rehabilitation (rehab) units allow firefighters to rest, remove personal protective gear, drink fluids, and have their health status monitored while on an active scene. This is a vital strategy to protect FFs especially if they are engaged on scene for prolonged periods in extreme temperatures; particularly in weather conditions with a high heat index. Rehab operations should consider hot weather conditions, including temperature, relative humidity, and direct sunlight [NFPA 2015b]. The fire department routinely sets up rehabilitation during structural fires but did not have a formal rehabilitation set up during this prolonged and complicated extrication and rescue operation despite the oppressive heat and humidity that rescuers were working in. The weather conditions during this incident were hot and humid, which was reportedly exaccerbated by the heat radiating from the blacktop surface. Efforts were made to hydrate individuals during the operation. The AC did not take a break during the extrication rescue due to his involvement in the medical care of the trapped driver. The Chief did recognize the need to cool the members of his department and ordered all individuals to seek airconditioning in vehicles as soon as operations permitted.

NIOSH offers the following recommendations to help reduce the risk of sudden cardiac events among firefighters at this and other fire departments across the country.

Recommendations

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

Discussion: Guidance regarding the content and frequency of these medical evaluations can be found in NFPA 1582 [NFPA 2018]. These evaluations are performed to determine a firefighter's medical ability to perform duties without presenting a significant risk to the safety and health of himself/herself or others. This medical evaluation should be consistent with the requirements of NFPA 1582.

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Recommendation #2: Ensure firefighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment 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, 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 personal protective equipment they must wear during various types of emergency operations.

Since AC reportedly had an episode of chest pain within the previous month, he should have been evaluated by a cardiologist for return to duty clearance. The FD did not provide any documentation that such an evaluation was done. This could have been due to the AC failure to report this incident to the FD or other miscommunications but this should be investigated by the FD to ensure that similar potential sentinel events in other staff are not missed. Depending on the outcome of the medical evaluation, it is possible that the near total occlusion of the left anterior descending coronary artery (LAD) (also known as a widowmaker) may have been identified and treated prior to the fatal heart attack that occurred following the AC's participation in the prolonged extrication.

Recommendation #3: Consider incident scene rehabilitation (rehab) during rescue operations as dictated by weather conditions and the work performed.

The Incident Commander considers the circumstances of each incident in determining the need for rehabilitation [NFPA 2015b]. As recommended in NFPA 1584, members performing in hot environments should be provided an area that includes shade and/or air conditioning and a place to sit [NFPA 2015b]. Rehab should be located sufficiently far away from the effects of the operation so that members can safely remove their personal protective equipment and can be afforded physical and mental rest [NFPA 2015b]. On-scene rehab should be staffed, include at least basic life support, and have fluid and food available [NFPA 2015b].

Recommendation #4: 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 2015a], the *IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative (WFI)* [IAFF, IAFC 2018], and *Firefighter Fitness: A Health and Wellness Guide* [Schneider 2010]. 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 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].

The FD has exercise equipment available to members but does not have a wellness/fitness program. NIOSH recommends that all firefighters have access to a well-structured health and wellness program such as the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs Wellness/Fitness Initiative (IAFC WFI).

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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 the former Lead for the Cardiac and Medical LODD Investigations Team in Cincinnati.

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Appendix A
Autopsy Findings

Structural

- Borderline cardiomegaly (heart weighed 550 grams)
- Concentric left ventricular hypertrophy (left ventricular thickness of 1.5 cm)
- No necrosis

Microscopic

- Focal mature fibrosis of left ventricle
- Isolated focus of chronic inflammation with possible myocyte damage on lateral portion of left ventricle
- Scattered areas of hypertrophic myocytes; myocytes well-ordered

Coronary arteries

- No intracoronary thrombus
- Coronary arteries free of significant luminal narrowing
- Midsegment of left anterior descending coronary artery has myocardial bridging (2 mm deep)

Normal cardiac valves

No evidence of a pulmonary embolus (blood clot in the lung arteries)

Blood analysis

- Negative for drugs of abuse

Author's Discussion:

Predicted normal heart weight 452 grams (ranges between 342 and 595 grams as a function of sex and body weight), according to research in Silver and Silver [2001].

Left ventricular thickness of 1.5 cm is high 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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