1000 FREDERICK LANE, MORGANTOWN, WV 26508 • 304.285.5916

Firefighter Suffers Cardiac Arrest at Motor Vehicle Accident—Georgia

Executive Summary

On July 14, 2020, a 50-year-old male career firefighter (FF) became disoriented and suffered a sudden cardiac arrest while performing extraction work at the scene of a motor vehicle accident. On-scene emergency medical services (EMS) immediately initiated cardiopulmonary resuscitation (CPR) and provided manual defibrillation. Advanced cardiac life support was provided on-scene and enroute to the emergency department (ED). The FF went into full cardiac arrest by a return of spontaneous circulation. In the ED, electrocardiograms (EKGs) indicated that the FF was having a myocardial infarction (heart attack). The FF was taken to the cardiac catheterization laboratory, but no obstructions were found. The FF remained in the hospital in intensive care for six days but never regained consciousness. He suffered post-event anoxic brain injury and was pronounced dead on July 20, 2020.

The Medical Examiner's report listed the cause of death as coronary atherosclerotic disease and hypertensive heart disease. National Institute for Occupational Safety and Health (NIOSH) investigators concluded that the physical work of the extrication in the heat initiated a sudden cardiac arrest in the FF with underlying cardiac disease.

Key Recommendations

- *Key Recommendation 1: 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.*
- *Key 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.*
- *Key Recommendation 3: Phase in a mandatory comprehensive wellness and fitness program for firefighters.*

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

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Introduction

On July 14, 2020, a 50-year-old male career firefighter (FF) suffered sudden cardiac arrest while performing extrication work to rescue a victim of a motor vehicle accident. The FF was admitted to the hospital but never regained consciousness, and he died on July 21, 2020. The U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this fatality on August July 22, 2020. NIOSH contacted the affected public safety department on September 15, 2020, to gather initial information. In July of 2021, a contractor for the NIOSH Firefighter Fatality Investigation and Prevention Program (the NIOSH investigator) conducted a series of phone calls and reviewed records of the incident.

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

- *Fire Chief*
- *Incident Commander*
- *Medical examiner*

The NIOSH investigator reviewed the following documents:

- *Incident report*
- *Witness statements from Police and Fire*
- *Emergency medical services (EMS) (ambulance) report*
- *Hospital emergency department (ED) records*
- *Autopsy report*

Investigation

On July 14, 2020 at 0800 hours, the FF began a 24-hour shift at Station A after working the previous 24 hours at Station B (as an additional shift) where he ran no calls during his shift. The FF was the only person staffing Station A and had run a medical call at approximately 1000 hours. He drove Station A's fire engine to the scene and assisted the ALS crew in loading the patient into the ambulance. The medics that he assisted reported that there was nothing out of the ordinary in his response or demeanor. At 1623 hours, the FF was dispatched for a motor vehicle accident involving a

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head-on collision involving two motor vehicles. The temperature was 91°F and 42% humidity (weatherunderground.com) and the firefighter responded in full bunker gear.

The FF arrived on scene at 1630 hours, just behind two Sherriff's Deputies to find an overturned vehicle resting near a guardrail with an entrapped driver. The FF carried extrication tools (power unit, ram, cutters, spreaders) to the vehicle and also pulled a handline to protect against fire risk. An officer arrived on scene within a minute of the FF, and a service truck, also staffed by a single firefighter, arrived on-scene at 1633. The officer asked about the FF's assessment of the scene and assumed incident command. The FF removed the rear driver's side door and was working with the other firefighter to continue the extrication when the officer noted that the FF looked exhausted, sweaty, and had a flushed appearance. Another firefighter asked the FF if he was okay, and he replied that he needed to get to the other side of the vehicle, a response that made little sense given the work that needed to be done. The officer told the FF that he needed to sit down and rest.

At 1633 hours, the ambulance arrived on scene. At approximately 1635 hours, the FF stopped his rescue work and walked toward the front of car. After he indicated that he needed to get to the other side of the car and then shouted, "I am stuck." A Sherriff's Deputy who was nearby and heard the claim, ran to his side and found that the FF was not stuck but was shaking uncontrollably. The Sherriff's Deputy and another Deputy saw the FF's knees begin to buckle and, along with EMS personnel, assisted the FF to the ground. As on-scene personnel began to remove his bunker gear, the FF became apneic and unresponsive. Ambulance personnel immediately initiated cardiopulmonary resuscitation (CPR) and provided oxygen via bag-valve mask at 15 liters per minute (lpm). At 1638 hours, the FF was placed on a cardiac monitor that showed the FF was in pulseless ventricular fibrillation (V-Fib) and he was shocked. The FF took several gasping breaths and returned to full cardiac arrest. The FF was rolled onto a backboard and lifted to a stretcher and moved into the ambulance. Cardiac medications (epinephrine, etomidate, and midazolam) were administered. The first attempt at intubation was unsuccessful, but the second attempt, using King Vision Channeled Blade® and a 7.5 endotracheal tube was successful. Tube placement was confirmed by condensation in tube, end tidal carbon dioxide ($EtCO_2$) monitoring, equal breath sounds, and symmetrical chest rise. Additional cardiac medications were given and at 1650 hours the ambulance departed the scene for the ED.

At 1652 hours, the FF had a return of spontaneous circulation (ROSC). His vitals were: heart rate (HR) = 140 beats per minute (bpm), blood pressure = 59/20 millimeters of mercury (mmHg), oxygen saturation 87% (with O_2 being administered), and blood glucose of 190 milligrams per deciliter (mg/dL). Dopamine was administered. Over the next couple of minutes, the FF remained in sinus tachycardia with strong femoral and carotid pulses. At approximately 1700 hours, the FF's heart rhythm returned to ventricular tachycardia (V-Tach), which quickly progressed to V-Fib and the FF again became unresponsive. Chest compressions were restarted, and the FF received a second shock. Another dose of epinephrine (5^{th} dose) was given. The FF had another ROSC with a sinus rhythm. The FF was breathing on his own and fighting against the ET tube, so he was sedated with an additional dose of midazolam. At approximately 1708 hours, as the ambulance was arriving at the ED, the FF returned to a rhythm of V-Tach. Cardioversion was performed with conversion to sinus tachycardia. At 1715 hours, the FF was moved into a trauma room and transferred to a hospital bed.

In the ED, the FF had additional episodes of ventricular tachycardia and additional shocks were provided. A CT of the head found no acute intracranial abnormalities. An echocardiogram showed normal left ventricular ejection fraction, but severe concentric left ventricular hypertrophy was noted. Blood analysis showed elevated troponin I (0.07 nanograms per milliliter [ng/mL]; normal < 0.03 ng/mL) suggestive of cardiac tissue damage. An EKG showed ST elevation (in aVR and V1 leads) and diffuse ST segment depression. A repeat EKG showed persistent ST elevation in a VR and V1 leads and new ST elevation in lead III indicating the FF was having a myocardial infarction (ST elevation myocardial infarction, STEMI). After consulting with cardiology, the FF was sent to the cardiac catheterization laboratory (Cath lab). The FF underwent left heart catheterization which noted mild atherosclerotic disease (30%–40% stenosis) of the left anterior descending (LAD) coronary artery. The LAD supplies the anterior area of the heart, which the EKG findings indicated as the site of the ischemia. The FF was transferred to intensive care unit where targeted temperature protocols were initiated.

The FF remained in intensive care, on mechanical ventilation for 8 days. On the second day of his admission, he developed deep vein thrombosis in the left leg. Despite broad consultation with cardiovascular medicine, cardiology, and neurology, the etiology of his cardiac arrest remained unclear. During the course of his intensive care treatment, the FF had severe neurological compromise. The etiology of the post-event neurological deterioration was also unclear, though it was noted that this could have been due to cerebral hypoxia during his cardiac arrest. Repeat head CT revealed severe anoxic encephalopathy. On July 21, 2020, at 1520 hours, the FF was pronounced brain dead and life support was discontinued.

Medical Findings

The autopsy report listed the cause of death as coronary atherosclerotic disease and hypertensive heart disease. Because of the prolonged hospital stay, only a records review and external examination were performed by the medical examiner. In the opinion/summary section of the report, the medical examiner noted that the FF had a clinical history of hypertension, coronary angiogram evidence of coronary atherosclerotic disease, and EKG findings of a myocardial infarction. The FF was not a smoker. He was 5’11” and weighed 280 lbs. giving him a body mass index (BMI) of 39. A BMI > 30 is considered obese [Centers for Disease Control and Prevention 2020]. Hospital records indicated that he only had a past medical history of hypertension.

Department

This fire department has 12 stations, each staffed by a single career firefighter who works a 24 hour on, 48 off shift. Firefighters often work additional shifts outside of this schedule either for overtime pay or in trade with another firefighter. There are 15 uniformed members, serving a population of over 28,000 residence in an area of approximately 280 square miles.

The FD requires preplacement medical evaluations for applicants. The evaluations are performed by an occupational health clinic that provides the medical evaluations on a contract basis. Components of the medical evaluation include the following:

- *Complete medical history*
- *Physical examination (height, weight, blood pressure, pulse, and respiratory rate)*

- *Complete blood count*
- *Urinalysis*
- *Urine drug screen*
- *Audiogram*
- *Vision test*
- *Respirator use questionnaire*
- *Spirometry*
- *Resting EKG*

The department does not require annual medical evaluations for members but does perform respiratory fit test testing. Members are required to provide medical clearance from a personal physician or the City Occupational Health clinic following a serious injury or illness.

The department does not offer a comprehensive wellness/fitness program as recommended by the International Association of Firefighters//International Association of Fire Chiefs Wellness Fitness Initiative [IAFF and IAFC 2018]. The FD has some training equipment in each fire station and there is a well-equipped gym for county employees near headquarters. The employee insurance offered through the department offers a wellness physical.

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 (also known as coronary artery disease or CAD) is the most common risk factor for cardiac arrest and sudden cardiac death [Myerburg and Castellanos 2015]. Hypertensive heart disease also increases the risk for sudden cardiac events. Sudden cardiac events can be triggered by strenuous work, or emotional stress, both of which can precipitate a myocardial infarction or a fatal arrhythmia [Katritsis et al. 2016; Myerberg and Castellanos 2015]. Although most individuals suffering an acute myocardial infarction (MIs) have obstructive coronary artery disease, approximately 1%–15% of acute MIs occur in the absence of obstructive disease and are often termed myocardial infarction with non-obstructive coronary arteries (MONICA) [Agewall et al. 2017; Gasior et al. 2020]. Although the phenomenon is not well understood, there are several potential mechanisms for MONICA, including myocarditis, coronary microvascular spasm, coronary spasm [Gasior et al. 2020]. In this case, the FF was performing strenuous work on a hot day which may have served as a triggering event for coronary artery vasospasm severe enough to lead to a myocardial infarction as evidenced by EKGs and cardiac enzymes in the absence of obstructive atherosclerotic disease. Coronary artery vasospasm does not leave any anatomical evidence to be found on autopsy. However, it is possible that a vasospasm occurred in the area of the LAD which was already partially occluded (30%–40%) by atherosclerotic plaque which may have reduced the blood flow to the anterior portion of the heart enough to result in the ischemia noted on the EKG.

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 2005; Tavora et al. 2012]. The FF had a reported history of hypertension and the echocardiogram performed in the hospital showed anatomical remodeling of the heart consistent with chronic hypertension with concentric hypertrophy.

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 arrhythmogenic changes in individuals with underlying cardiovascular disease [Smith et al. 2016]. Research relying on autopsy data found that the majority of firefighter duty-related sudden cardiac deaths have coronary artery disease and cardiomegaly/left ventricular hypertrophy [Smith et al. 2018] and this is also true for young firefighters [Yang et al. 2013]. To reduce the risk of sudden cardiac events or other incapacitating conditions among firefighters, the National Fire Protection Association (NFPA) developed 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments [NFPA 2018]. Guidance in the 1582 Standard recommends annual risk assessment of all firefighters ≥ 40 years old with a "Heart Risk Calculator" that takes into account age, sex, blood pressure, smoking status, etc., to estimate 10-year risk of sudden cardiac events or stroke [ACC/AHA 2018; NFPA 2018].

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. The FF did not have an annual occupational medical evaluation. The FF had been hired in 2018 and but the requirement that new hires have a medical evaluation was waived because he had been a firefighter in a neighboring county-based FD, and thus he was only required to pass a drug screen before being hired.

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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 department 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 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.

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 Firefighters* [NFPA 2015], the *IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative (WFI)* [IAFF and 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 workdays [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 department has exercise equipment available to members but does not have a specific wellness/fitness program. The county provides health insurance that includes a wellness benefit. NIOSH recommends that all firefighters have access to a well-structured health and wellness program such as the IAFF/IAFC WFI.

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Investigator Information

This incident was investigated by the NIOSH Firefighter 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 Firefighter Fatality Investigation and Prevention Program, Medical LODD Investigations Team, during this investigation. Judith Eisenberg, MD, MS, provided medical consultation and contributed to the report. Dr. Eisenberg is Lead for the Medical LODD Investigations Team in Cincinnati.

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