Firefighter Suffers Cardiac Event Following Residential Fire – NY

Executive Summary

On May 4, 2015, at 0700 hours, a 54-year-old male career fire fighter (FF) began his 24-hour shift. At 1058 hours, the FF and his crew were dispatched to a residential fire with reports of a possible victim. The FF assisted in the rescue attempt and fire suppression activities for approximately 40 minutes, when he reported to incident scene rehabilitation. During his 20 minutes in rehab the FF reported no signs or symptoms of distress. However, as the FF was preparing to take his gear to the apparatus, he reported left shoulder pain and was transported by ambulance (no lights or siren) to the local emergency department (ED). As the FF was walking into the ED at 1224 hours, he reported severe chest pain and shortness of breath. Shortly thereafter, he suffered a cardiac arrest. The FF was successfully resuscitated but he remained in cardiogenic shock. An electrocardiogram (ECG) showed findings consistent with an acute heart attack and an emergency cardiac catheterization showed complete occlusion of his left main coronary artery. The catheterization and efforts to open the occluded artery were complicated by two episodes of cardiac arrest and referral for emergency coronary artery bypass graft (CABG) surgery. Despite these intensive measures, the FF had suffered anoxic brain damage. The next day, after discussion with family members, the medical staffed withdrew life support measures and shortly thereafter the FF was pronounced dead.

The autopsy and the death certificate, completed by the County Deputy Medical Examiner, listed "myocardial infarction due to atherosclerotic cardiovascular disease" "in a fireman sustained during a housefire." The autopsy revealed cardiac hypertrophy, marked coronary atherosclerotic stenosis in two vessels, and evidence of infarction (myocardium had area of reddish mottled hemorrhage). NIOSH investigators concluded that the physical stress of responding to and participating in fire suppression activities at the structure fire triggered a heart attack which resulted in his cardiac arrest and subsequent death.

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Key Recommendations

- *Ensure that all fire fighters receive an annual medical evaluation consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.*
- *Ensure fire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.*
- *Phase in a mandatory comprehensive wellness and fitness program for fire fighters.*

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 May 4, 2015, a 54-year-old FF suffered a fatal heart attack following fire rescue and suppression activities at a residential fire. The U.S. Fire Administration notified NIOSH of this fatality on May 6, 2015. NIOSH contacted the affected fire department (FD) on May 7, 2015, to gather additional information and on February 8, 2016, to initiate the investigation. On February 28, 2016, a contractor for the NIOSH Fire Fighter Fatality Prevention and Investigation Program (the NIOSH investigator) conducted an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- Captain who served as chief of operations during the fire
- Crew members
- FF's wife
- NIOSH personnel reviewed the following documents:
- FD standard operating guidelines
- FD annual report for 2015
- FD cause and origin report
- Police department investigative report
- Emergency medical service (ambulance) report
- Hospital ED records
- Hospital catheterization laboratory records
- Hospital operation room records
- Hospital intensive care unit records
- Death certificate
- Autopsy report

Investigation

On May 4, 2015, at 0700 hours a 54-year-old male career FF began his 24-hour shift. The day began with an update from personnel on the previous shift, safety inspection of personal protective equipment, and house cleaning. At 0816 hours the FF and his engine crew responded to an automatic fire alarm at the hospital. At 0825 hours the crew retuned to the station and prepared for daily fire hydrant inspections. At 0850 hours the crew of Engine 2 left the fire station to perform hydrant inspection duties.

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At 1058 hours, while they were still performing hydrant inspections, the FF and his engine crew were dispatched to a single family (two-story) structure fire with reports of possible trapped victims. The FF's engine arrived on scene at 1102 hours. It was a clear, warm spring day (77 °F, 33% humidity, winds out of the west at 5.8 mph) [Weather Channel 2016]. On arrival, the front of the building was fully involved with fire coming out the windows. Neighbors confirmed there was a victim in the building. One of the three engines used its master stream to knock down the fire and permit entry of search crews.

The FF exited his fire apparatus and established water supply. The FF then walked approximately 50 feet to the front of the house. After donning full personal protective equipment, including a 45-minute self-contained breathing apparatus (SCBA), the FF assisted another fire fighter in advancing a hoseline through the front door to protect the stairway as other fire fighters searched for victims upstairs. While the FF and his partner protected the stairway, they used their hoseline to suppress fire in the living room adjacent to the stairway.

Once the search crew had located the victim on the second floor, they radioed for help to remove the victim. The FF and his partner went upstairs and helped move the victim around the banister and down the first third of the stairway. After handing the victim off to other fire fighters on the stairs, the FF and his partner used a handline to fight fire in a bedroom toward the front of the house. After knocking down the fire, fire fighters began pulling down the ceiling to check for fire extension. The crew that completed the victim removal were sent to incident-scene rehabilitation and one fire fighter was transported to the hospital due to a shoulder injury he sustained when removing the victim.

At approximately 1140 hours the FF and his partner exited the building and were assigned to incident scene rehabilitation by the chief of operations. At this time, the initial fire and rescue operations were completed. In rehab, the FF and his partner doffed their helmets, SCBA, and coats and were provided fluids. While in rehab, the FF talked with his partner about the fire, but never complained of any symptoms or showed any signs of a health problem.

At approximately 1205 hours, as the FF and others were gathering their gear and preparing to reload the hoseline, the FF reported pain/tightness in his left shoulder. The FF was told to have it evaluated at the hospital, and he walked a few feet to on scene emergency medical services personnel.

The FF reported to emergency medical services personnel that he had been setting up hydrants and had pulled a victim out of the fire and felt as though he had pulled a muscle. He indicated he had pain in his left shoulder that radiated to his back. The FF insisted on walking approximately 100 ft to the ambulance which departed for the ED at 1214 hours and arrived at 1218 hours. Enroute to the ED, the FF began complaining of shortness of breath. He was provided oxygen via nasal cannula and stated that he felt better. The FF insisted on walking into the ED.

The FF was admitted to the ED at 1224 hours. His initial vital signs included a pulse rate of 72 beats per minute (normal resting is 60–100 beats per minute), respiratory rate of 20 breaths per minute (normal resting is 6–12 breaths per minute), arterial oxygen saturation of 98% (normal resting is 94–

100%), and blood pressure of 71/57 millimeters of mercury (normal resting systolic is between 90-120 and normal resting diastolic is between 60-80 millimeters of mercury). He then reported severe (8 on a 10-point scale) chest pain. The FF was assisted to a room, and, as he sat down on the bed, he collapsed and became unresponsive.

CPR was initiated by hospital personnel and the FF regained a heart rhythm and pulse in about 45 seconds with no medications or shock. His ECG showed wide QRS and ST segment elevations in the anterior leads consistent with a heart attack. Subsequently, the FF had two episodes of non-sustained ventricular tachycardia and again became unresponsive. The FF was intubated and an intravenous line was placed as cardiac resuscitation medications were administered (e.g., vasopressors for cardiogenic shock). The cardiac catheterization team was mobilized.

At approximately 1300 hours the FF was taken to the cardiac catheterization suite where a thrombus completely occluding his left main coronary artery was identified. Several efforts to open the occluded artery (thrombectomy) were made before the FF was transferred to the surgical team for emergency coronary artery bypass graft surgery. During the catheterization, the FF had complications, including 1) two separate episodes of cardiac arrest requiring CPR and multiple defibrillations, and 2) cardiogenic shock requiring placement of a ventricular assist device. The FF's bypass surgery lasted almost 7 hours during which two vessels were grafted and a different type of left ventricular assist device was placed. Despite these heroic measures, the FF suffered anoxic brain damage. The next day a cold caloric test and an apnea test both revealed brain death. After discussion with the FF's family, life support was withdrawn; the FF died on May 5 at 1420 hours.

Medical Findings

The death certificate and the autopsy report, completed by the Deputy Medical Examiner, listed "myocardial infarction due to atherosclerotic cardiovascular disease in a fireman sustained during a housefire" as the cause of death.

NIOSH was unable to identify his primary care physician (PCP) or locate medical records other than those from this incident. According to the ED encounter form, the FF listed a history of high blood cholesterol and his sister reported that he might have taken cholesterol lowering medication in the past. The ED encounter form also listed a history of hypertension, which his wife later reported as unlikely. The FF did not smoke and was physically active, participating in cardiovascular and resistance training almost every day. He was 71 inches tall and weighed 200 pounds, giving him a body mass index of 27.9 kilograms per meters squared [CDC 2015].

Fire Department

At the time of the NIOSH investigation, the FD consisted of three fire stations with 62 career uniformed personnel. It served 33,000 residents in a geographic area of 4.2 square miles. In 2015, the FD responded to over 4,300 incidents, including 135 fire calls and more than 2,600 rescue and emergency medical calls.

Employment and Training

The City is responsible for developing a list of certified civil service candidates from which the FD hires fire fighters. Applicants must be 18 years of age; have a high school diploma or a general education development (GED) diploma; have a valid state driver's license; pass a written aptitude exam; and pass a physical agility test. Once the certified list is sent to the FD, the Chief and Deputy Chief interview candidates in the top band. Successful candidates are offered conditional employment subject to passing a background check and a preplacement medical evaluation. The new member is on probation for 1 year. The new member must complete training at a state-certified regional training Academy (usually 11–17 weeks) that includes Fire Fighter I and II, and Hazardous Material Operations. New members are placed on a 24-hour shift and work 24 hours on duty, 72 hours off duty. New fire fighters are assigned to a shift with an opening and are assigned to fill positions that are open due to daily staffing fluctuations. The FF was certified as a Fire Fighter II and Driver/operator. He had 24 years of fire fighting experience.

Preplacement Medical Evaluation

The City requires preplacement medical evaluations for all applicants. Evaluations are conducted by a contract physician for the City. Components of this evaluation include the following:

- Complete medical history
- Physical examination (height, weight, blood pressure, pulse, and respiratory rate)
- Complete blood count with lipid panel
- Urinalysis
- Urine drug screen
- Audiogram
- Vision test
- Respirator use questionnaire
- Spirometry
- Resting ECG
- Chest x-ray (baseline)

Once this evaluation is complete, the contracted physician makes a determination regarding medical clearance for firefighting duties and forwards this decision to the FD office. The FD did not have preplacement medical records for this FF.

Periodic Medical Evaluations/Return to Work Medical Evaluations

The FD does not require medical evaluations for incumbent fire fighters. Medical clearance to wear SCBA is required. Members injured on duty may be evaluated by their own physician except for serious injuries, which require that a City-appointed physician evaluate the member. Members who miss three or more shifts due to illness must be evaluated by their PCP who makes the determination regarding return to work.

Wellness/Fitness Programs

The FD does not have a comprehensive wellness/fitness program as recommended by the IAFF/IAFC Wellness Fitness Initiative [IAFF, IAFC 2008]. Some fitness equipment is available in the fire stations and members are allowed to exercise while on duty. The FF performed resistance training exercise for about an hour on every shift and regularly went to a local gym where he did aerobic and resistance exercise.

Discussion

Sudden Cardiac Events

In the United States, atherosclerotic coronary heart disease is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development are grouped into non-modifiable and modifiable. 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 2015; NHLBI 2015]. The FF had two non-modifiable risk factors (age and male gender). The FF probably had high cholesterol, but the diagnosis of hypertension is less clear. Despite only having a few coronary heart disease risk factors, at autopsy the FF was found to have "marked coronary artery atherosclerosis."

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2013]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion. Heart attacks (myocardial infarctions) typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply. This sudden blockage is primarily due to blood clots (thromboses) forming on top of atherosclerotic plaques [Libby 2013]. Establishing a recent (acute) heart attack requires any of the following: characteristic ECG changes, elevated cardiac enzymes, or coronary artery thrombus. In this case, the FF had a coronary artery thrombus identified during cardiac catheterization; it completely occluded the left main coronary artery.

Physiological Stress of Firefighting

Heart attacks and sudden cardiac death can be triggered by heavy physical exertion [Mittleman 1993; Willich 1993; Albert et al. 2000]. Among fire fighters, sudden cardiac events have been associated with or triggered by alarm response, fire suppression, and heavy exertion during training (including physical fitness training) [Kales et al. 2003; Kales et al. 2007; NIOSH 2007]. The FF performed strenuous firefighting activity including: establishing water supply at a hydrant, advancing a hoseline into the interior of a working structure fire, assisting with victim rescue, and overhaul (pulling down the ceiling) to check and extinguish any fire extension. These activities would be considered heavy physical activity [Gledhill and Jamnik 1992; Ainsworth et al. 2011]. The heart attack that preceded the FF's cardiac death was probably triggered by the physical exertion associated with his activities at the structure fire.

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 (NFPA) 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. The FF did not have a medical evaluation at work so it is unclear if he should have been referred for an exercise stress test, or if he had other medical conditions that should have been referred for further evaluation or workup.

Recommendations

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

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 [NFPA 2013b; IAFF, IAFC 2008]. These evaluations are performed to determine a fire fighter's medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. If a fire fighter receives a medical evaluation by his PCP, the results of this evaluation must be shared with the FD physician who can then make a determination regarding medical fitness for duty.

Recommendation #2: Ensure fire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

According to NFPA 1582 and the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, the FD should have an officially designated physician who is responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty [NFPA 2013a; IAFF/IAFC 2008]. 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 fire fighters perform, as well as the personal protective equipment they must wear during various types of emergency operations. In addition, this physician should oversee all fitness for duty recommendations provided by PCPs and have the final authority for all medical fitness for duty decisions.

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

Guidance for fire department wellness/fitness programs to reduce risk factors for cardiovascular disease and improve cardiovascular capacity is found in NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*, the IAFF/IAFC *Fire Service Joint Labor Management Wellness/Fitness Initiative*, the U.S. Fire Administration *Health and Wellness Guide for the Volunteer Fire and Emergency Services*, and in *Firefighter Fitness: A Health and Wellness Guide* [USFA 2009; IAFF, IAFC 2008; NFPA 2015; 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 [Stein et al. 2000; Aldana 2001]. Fire service health promotion programs have been shown to reduce coronary heart disease risk factors and improve fitness levels, with mandatory programs showing the most benefit [Dempsey et al. 2002; Womack et al. 2005; Blevins et al. 2006]. 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 non-occupational healthcare costs [Kuehl et al. 2013]. The FD does not have a wellness/fitness program. The FF regularly exercised at the station on duty days and at the gym on days off. Nonetheless, NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a wellness/fitness program.

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio. Denise L. Smith, Ph.D, led the investigation and coauthored the report. Dr. Smith is professor of Health and Exercise Sciences, and Director of the First Responder Health and Safety Laboratory at Skidmore College. She is a member of the NFPA Technical Committee on Occupational Safety and Health. Dr. Smith was working as a contractor with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component during this investigation. Thomas Hales, MD, MPH, provided medical consultation and coauthored the report. Dr. Hales is a member of the NFPA Technical

Committee on Occupational Safety and Health, and Vice Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).

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Appendix A

Autopsy Findings

- Atherosclerotic Cardiovascular Disease
  - Cardiac hypertrophy (heart weighed 510 grams; predicted normal weight is 371 grams [ranges between 95 and 489 grams as a function of sex, age, and body weight]) [Silver and Silver 2001]
    - LV wall – 1.1 centimeters (cm)
      - 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]
    - RV wall - .2 cm
      - Normal at autopsy is 0.2–0.7 cm with an average of 0.35–0.39 cm [Hutchins and Anaya 1973; Murphy et al. 1988]
      - Normal by echocardiography 0.7–2.3 cm [Armstrong and Feigenbaum 2001]
  - Marked coronary artery atherosclerotic stenosis
    - Coronary artery thrombus – 100% occlusion of left main coronary artery (based on medical report)
    - 70-80% stenosis in left main and proximal left anterior descending coronary artery
    - 10% stenosis on right coronary artery
    - Myocardial infarction – left ventricle; 6.5 x 5.8 x 4.2 cm reddish mottled hemorrhage
  - Microscopic examination
    - Sections of left ventricular myocardium with necrotic myocytes, contraction bands, hemorrhage, and intra-parenchymal neutrophils
    - Sections of coronary arteries show a marked degree of luminal stenosis with myointimal hyperplasia, cholesterol deposition, mineralization and foci of chronic inflammation.
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Negative blood test for drugs and alcohol

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