2014
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Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

A summary of a NIOSH fire fighter fatality investigation *August, 2014*

Assistant Fire Chief Suffers Fatal Heart Attack While Operating an Engine at a Residential Structure Fire – Pennsylvania

Executive Summary

On November 20, 2013, at 2311 hours, a 58-year-old male volunteer assistant fire chief ("the AC") responded to a structure fire. After driving Engine 9 to the scene, he prepared to charge a 2-inch handline when he developed difficulty breathing, nausea, and vomiting. About 5 minutes later crew members noted the AC having difficulty prepping the handline, and the fire chief requested an ambulance.

The ambulance arrived 2 minutes later, and emergency medical technicians began basic life support. Oxygen was given via bag-valve-mask as the AC was placed onto a stretcher. The AC became unresponsive 20 seconds later (2334 hours). The AC was placed into the ambulance as cardiopulmonary resuscitation (CPR) began. En route to the hospital's emergency department (ED), an automated external defibrillator (AED) advised to shock, and a shock was administered without a change in the AC's clinical status. Paramedics from an advanced life support unit met the ambulance en route (2338 hours) at which time the AC was intubated, intraosseous venous access was obtained, and advanced cardiovascular life support resuscitation protocols were initiated. The AC was still in cardiac arrest (asystole) when the ambulance arrived at the ED (2355 hours). After approximately 5 minutes of treatment in the ED, the AC was pronounced dead at 0000 hours on November 21, 2013.

The death certificate completed by the county coroner listed "acute myocardial infarction" as the cause of death. The autopsy completed by the forensic pathologist revealed an acute plaque rupture and thrombus in the AC's right coronary artery, severe coronary artery disease (CAD), an old (remote) heart attack, and stents in the left anterior descending coronary artery and circumflex coronary artery. Given the AC's underlying heart disease, NIOSH investigators concluded that responding to the structure fire and the physical stress of operating the engine's pump panel probably triggered the AC's heart attack, which resulted in his death.

NIOSH investigators offer the following recommendations to reduce the risk of heart attacks and sudden cardiac arrest among fire fighters at this and other fire departments.

Provide preplacement and annual medical evaluations to all fire fighters in accordance with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to identify fire fighters at increased risk for coronary heart disease (CHD).

Ensure exercise stress tests are performed on fire fighters at increased risk for CHD.

Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

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Assistant Fire Chief Suffers Fatal Heart Attack While Operating an Engine at a Residential Structure Fire – Pennsylvania

Executive Summary (cont.)

Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

Perform a candidate and an annual physical performance (physical ability) evaluation.

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

Conduct annual respirator fit testing.

Introduction & Methods

On November 20, 2013, a 58-year-old male volunteer assistant fire chief suffered a heart attack while operating a fire engine at a structure fire and died less than an hour later. NIOSH was notified of the fatality by the U.S. Fire Administration on November 22, 2013. NIOSH contacted the affected fire department on November 26, 2013, to gather additional information and on February 5, 2014, to initiate the investigation. On March 31, 2014, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Prevention and Investigation Program and a physician from the NIOSH Health Hazard Evaluation Program traveled to Pennsylvania to investigate the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire chief
- Assistant chief
- Crew members
- Chief's spouse

NIOSH personnel reviewed the following documents:

- Fire department standard operating procedures
- Fire department annual report for 2013
- Primary care physician records
- Emergency medical service (ambulance) report
- Hospital ED report
- Death certificate
- Autopsy report

Investigative Results

Incident. On November 20, 2013, at 2311 hours, the fire department was dispatched to a residential structure fire near the fire station. The AC responded from his home to the fire department where he drove Engine 9 to the scene, arriving at 2321 hours. Weather conditions included a temperature of 32 degrees Fahrenheit (°F), relative humidity of 36% with a wind chill factor of 25°F [NOAA 2013].

Tanker 9 also responded along with 11 fire department personnel in their private vehicles. Heavy smoke and some flame showed from an enclosed porch on the "C" side of the structure. Fire fighters pulled 200 feet of 2-inch preconnected hoseline and advanced the line to the porch door as the AC readied the pumper to charge the hoseline. During this task the AC reported exposure to fire smoke without respiratory protection. The AC then experienced breathing difficulty with nausea and vomiting while climbing onto Engine 9's pump panel. After incorrectly reporting to crew members that the pump was operating, for unclear reasons he climbed into the cab and began "pressing buttons

Investigative Results (cont.)

on the dashboard." Because of his erratic behavior, the fire chief requested Ambulance 9 to their on-scene location (2326 hours).

The ambulance arrived 2 minutes later. The emergency medical technicians found the AC to have breathing difficulty, general weakness, and vomiting. He was assisted to the ambulance and placed onto a stretcher where oxygen was applied via bag-valve-mask. About 20 seconds later he became unresponsive. The stretcher was loaded into the ambulance, which departed the scene at 2334 hours. About 30 seconds later the AC stopped breathing, and his pulse stopped. CPR was begun. The AED was attached to the AC and advised a shock, which was administered without a change in the AC's clinical condition. Subsequent AED analysis advised no shocks; CPR continued.

An advanced life support unit with paramedics met the ambulance en route to the ED at approximately 2338 hours. Cardiac monitoring, intubation, and intraosseous cardiac resuscitation medications (no intravenous access could be gained) were initiated. The AC's heart rhythm remained in asystole for the remainder of the transport as CPR continued.

The ambulance arrived at the ED at 2355 hours. Inside the ED, CPR and ALS continued for an additional 5 minutes. A cardiac ultrasound was performed showing no cardiac activity. The AC was pronounced dead by the attending physician at 0000 hours on November 21, 2013, and resuscitation efforts were stopped.

Medical Findings. The death certificate completed by the county coroner listed "acute myocardial infarction" as the cause of death. The autopsy completed by the forensic pathologist found evidence of severe CAD including an old heart attack as shown by fibrosis of the left ventricular wall, stents in the left anterior descending coronary artery and circumflex coronary artery, and a new heart attack that occurred close to the time of death indicated by a recent plaque rupture and clot in the right coronary artery. Other pertinent autopsy findings are listed in Appendix A.

The AC had a history of CHD with a heart attack (myocardial infarction) diagnosed in 2004 followed by stent placement in two coronary arteries. In addition, he was being followed by his primary care physician for type 2 diabetes mellitus, hypertension, hypercholesterolemia, sleep apnea, and obesity. His prescription medications included metformin for diabetes mellitus, prevastatin for high cholesterol, and baby aspirin for CHD. It is unclear if he was prescribed a continuous positive airway pressure machine for sleep apnea. His most recent measurements included a blood pressure of 128/82 millimeters of mercury in July 2013, a blood glucose value of 161 milligrams per deciliter (mg/dL) (normal is 70–110) in April 2012, and a hemoglobin A1c (a measure of long-term blood sugar control) value of 7.8 (normal is <6.0) in April 2012. His most recent lipid values in October 2011 included a blood cholesterol level of 223 mg/dL (normal is 100–199), a triglyceride level of 178 mg/dL (normal is 0–149), a high density lipoprotein level of 42 mg/dL (normal is 30–60), and a low density lipoprotein level of 145 mg/dL [normal is 88–162].

In June 2007 the AC was diagnosed with sleep apnea based on symptoms and elevated body mass index (41). He was initially treated with continuous positive airway pressure but there was

Investigative Results (cont.)

no evidence he was compliant with the treatment [Gurubhagavatula et al. 2004; Somers et al. 2008]. NFPA 1582 considers untreated obstructive sleep apnea as a condition that could impair a fire fighter's ability to perform essential job tasks and recommends restricted duty until under treatment [Somers et al. 2008; NFPA 2013a].

Four months prior to his death the AC weighed 279 pounds and was 71 inches tall, resulting in a body mass index of 38.5 [CDC 2014]. Before this incident the AC had not recently complained of chest pain.

Description of the Fire Department

At the time of the NIOSH investigation, the fire department consisted of one fire station with 25 volunteer uniformed personnel. The fire department served 4,000 residents in a geographic area of 192 square miles. In 2013, the fire department responded to 155 incidents.

Membership and Training. The fire department requires volunteer fire fighter applicants to be 18 years of age, be a high school graduate or have a general educational development certificate, have a valid state driver's license, complete a screening questionnaire, and pass a screening committee interview and membership vote. The new member must pass a background check, attend six fire department meetings per year, and respond to 25% of the fire department's emergency calls. The AC was certified as a fire fighter II, driver/operator, emergency medical technician, fire instructor, in hazardous materials operations, and technical rescue. He had 43 years of fire fighting experience.

Preplacement and Annual Medical Evaluations. Preplacement and/or annual medical evaluations are not required by the fire department. Members injured on duty must be evaluated by their primary care physician. Once this evaluation is completed, the physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the fire chief. Medical clearance to wear a respirator and an annual self-contained breathing apparatus facepiece fit test are not required.

Health and Wellness Programs. The fire department does not have a wellness/fitness program, and exercise equipment is not available in the fire station. No annual job performance physical ability test is required for members. Although active, the AC did not participate in a structured physical fitness program.

Discussion

Atherosclerotic Coronary Heart Disease. In the United States, atherosclerotic CHD is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development include age older than 45, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes [Greenland et al. 2010; NHLBI 2012; AHA 2014]. The AC had known CHD plus three modifiable CHD risk factors: high blood cholesterol, diabetes, and obesity.

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

Discussion (cont.)

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 (thrombosis) forming on top of atherosclerotic plaques [Libby 2013]. In this case, an acute coronary artery thrombus was identified at autopsy, confirming an acute heart attack.

Cardiomegaly/Left Ventricular Hypertrophy. On autopsy, the AC was found to have left ventricular hypertrophy and an enlarged heart (cardiomegaly). Hypertrophy of the heart's left ventricle is a relatively common finding among individuals with long-standing hypertension, a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle) [Siegel 1997]. The AC had a history of hypertension and chronic cardiac ischemia. Left ventricular hypertrophy and cardiomegaly increase the risk for sudden cardiac death [Levy et al. 1990].

Occupational Trigger. Heart attacks and sudden cardiac deaths have been linked to heavy physical exertion [Mittleman et al. 1993; Albert et al. 2000]. Among fire fighters, fatal cardiac events have been associated with alarm response, fire suppression, and heavy exertion during training (including physical fitness training) [Kales et al. 2003; Kales et al. 2007; NIOSH 2007]. The AC's activities at the fire scene would have expended about 6 metabolic equivalents, which is considered moderate physical activity [Gledhill and Jamnik 1992; Ainsworth et al. 2011]. NIOSH investigators conclude the AC's sudden cardiac death was due to an acute heart attack triggered by responding to the fire scene and/or the physical exertion associated with fire ground activities.

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 AC's CHD was known since 2004, and according to NFPA 1582 the continuing presence of modifiable CHD risk factors (high cholesterol, diabetes mellitus, and hemoglobin A1c) should have restricted his participating in fire suppression tasks [NFPA 2013a]. This guidance from NFPA is similar to that of the American College of Cardiology/American Heart Association and the U.S. Department of Transportation for commercial truck drivers [Gibbons 2002; Blumenthal et al. 2007; NFPA 2013a].

Recommendations

NIOSH investigators offer the following recommendations to reduce the risk of heart attacks and sudden cardiac arrest among fire fighters at this and other fire departments.

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

Guidance regarding the content and frequency of these medical evaluations can be found in NFPA 1582 and in the International Association

Recommendations (cont.)

of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) Fire Service Joint Labor Management Wellness/Fitness Initiative [IAFF, IAFC 2008; NFPA 2013a]. These evaluations are performed to determine fire fighters' medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. Following this recommendation will require significant resources and may be particularly difficult for smaller fire departments to implement. The fire department is not legally required to follow the NFPA standard or the IAFF/IAFC guideline.

To overcome the financial obstacle of medical evaluations, the fire department could urge current members to get annual medical clearances from their private physicians. Another option is having the annual medical evaluations completed by paramedics and emergency medical technicians from the local ambulance service (vital signs, height, weight, visual acuity, and electrocardiogram). This information could then be provided to a community physician (perhaps volunteering his or her time), who could review the data and provide medical clearance (or further evaluation, if needed). The more extensive portions of the medical evaluations (e.g., exercise stress test) could be performed by a private physician at the fire fighter's expense (personal or through insurance), provided by a physician volunteer, or paid for by the fire department, city, or state. Sharing the financial responsibility for these evaluations between fire fighters, the fire department, the city, the state, and physician volunteers may reduce the negative impact on recruiting and retaining fire fighters.

Recommendation #2: Ensure exercise stress tests are performed on fire fighters at increased risk for CHD.

NFPA 1582, the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, and the American College of Cardiology/ American Heart Association recommend an exercise stress test for male fire fighters older than 45 with one or more CAD risk factors [IAFF, IAFC 2008; Gibbons et al. 2002; NFPA 2013a]. The AC was over the age of 45 and had known CHD and persistent CHD risk factors. A symptom-limiting exercise stress test may have identified his more recent condition, possibly leading to further evaluation and treatment.

Recommendation #3: Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

Guidance regarding medical evaluations and examinations for structural fire fighters can be found in NFPA 1582 and in the IAFF/IAFC Fire Service Joint Labor Management Wellness/ Fitness Initiative [IAFF, IAFC 2008; NFPA 2013a]. According to these guidelines, the fire department 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. The physician should review job descriptions and essential job tasks required for all fire department positions and ranks to understand the physiological and psychological demands of fire fighters and the environmental conditions

Recommendations (cont.)

under which they must perform, as well as the personal protective equipment they must wear during various types of emergency operations. It is unclear if the AC's personal physician was aware of NFPA 1582.

Recommendation #4: 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, and the National Volunteer Fire Council Health and Wellness Guide, and in Firefighter Fitness: A Health and Wellness Guide [IAFF, IAFC 2008; NFPA 2008; USFA 2009; 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 [Pelletier 2009; Baicker et al. 2010]. Fire service health promotion programs have been shown to reduce CAD risk factors and improve fitness levels, with mandatory programs showing the most benefit [Dempsey et al. 2002; Womack et al. 2005; Blevins et al. 2006; Poston et al. 2013]. A study conducted by the Oregon Health and Science University reported a savings of more than $1 million for each of four large fire departments implementing the IAFF/IAFC wellness/fitness program compared to four large fire departments not implementing a program. These savings were primarily due to a reduction of occupational injury/illness claims with additional savings expected from reduced future nonoccupational healthcare costs [Kuehl et al. 2013].The fire department did not have a wellness/fitness program and exercise equipment was not available in the fire station. Given the fire department's structure, the National Volunteer Fire Council program would be applicable [USFA 2009], but NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program.

The following recommendations are for general safety and health considerations.

Recommendation #5: Perform a candidate and an annual physical performance (physical ability) evaluation.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires the fire department to develop physical performance requirements for candidates and members who engage in emergency operations [NFPA 2013b]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2013b]. This could be incorporated into the annual task-level training program.

Recommendation #6: Provide fire fighters with medical clearance to wear SCBA as part of the fire department's medical evaluation program.

The Occupational Safety and Health Administration (OSHA) Revised Respiratory

Recommendations (cont.)

Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection [29 CFR 1910.134]. These clearance evaluations are required for private industry employees and public employees in states operating OSHA-approved state plans. Pennsylvania does not operate an OSHA-approved state plan; therefore the fire department is not required to ensure all members have been medically cleared to wear an SCBA [OSHA 2013]. However, we recommend voluntary compliance with this recommendation to improve fire fighter health and safety.

Recommendation #7: Conduct annual respirator fit testing.

The OSHA respiratory protection standard requires employers whose employees are required to use a respirator (e.g., an SCBA) to have a formal respiratory protection program, including annual fit testing [29 CFR 1910.134]. Therefore, each member should have his/her own SCBA facepiece or the fire department would have to ensure enough facepieces of each size were made available on each fire apparatus. As mentioned previously, Pennsylvania does not operate an OSHA-approved state plan; therefore, the fire department is not required to follow OSHA standards [OSHA 2013]. Nevertheless, NIOSH investigators recommend voluntary compliance with this standard to ensure proper fitting personal protective equipment to improve safety and health.

References

AHA (American Heart Association) [2014]. Understand your risk of heart attack. Dallas, TX: American Heart Association. [http://www.heart.org/HEARTORG/Conditions/HeartAttack/UnderstandYourRiskofHeartAttack/Understand-Your-Risk-of-Heart-Attack_UCM_002040_Article.jsp]. Date accessed: July 2014.

Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DR Jr, Tudor-Locke C, Greer JL, Vezina J, Whitt-Glover MC, Leon AS [2011]. Compendium of physical activities: a second update of codes and MET values. Med Sci Sports Exerc *43*(8):1575–1581.

Albert CM, Mittleman MA, Chae CU, Lee IM, Hennekens CH, Manson JE [2000]. Triggering of sudden death from cardiac causes by vigorous exertion. N Engl J Med *343*(19):1355–1361.

Baicker K, Cutler D, Song Z [2010]. Workplace wellness programs can generate savings. Health Affairs *29*(2):1–8.

Blevins JS, Bounds R, Armstrong E, Coast JR [2006]. Health and fitness programming for fire fighters: does it produce results? Med Sci Sports Exerc *38*(5):S454.

Blumenthal RS, Epstein AE, Kerber RE [2007]. Expert panel recommendations. Cardiovascular disease and commercial motor vehicle driver safety. [http://www.mrb.fmcsa.dot.gov/documents/CVD_Commentary.pdf]. Date accessed: July 2014.

References (cont.)

CDC (Centers for Disease Control and Prevention) [2014]. Assessing your weight. [http://www.cdc.gov/healthyweight/assessing/index.html]. Date accessed: July 2014.

CFR. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

Dempsey WL, Stevens SR, Snell CR [2002]. Changes in physical performance and medical measures following a mandatory firefighter wellness program. Med Sci Sports Exerc *34*(5):S258.

Gibbons RJ, Balady GJ, Bricker JT, Chaitman BR, Fletcher GF, Froelicher VF, Mark DB, McCallister BD, Mooss AN, O'Reilly MG, Winters WL Jr., Antman EM, Alpert JS, Faxon DP, Fuster V, Gregoratos G, Hiratzka LF, Jacobs AK, Russell RO, Smith SC Jr [2002]. ACC/AHA 2002 guideline update for exercise testing: a report of the American College of Cardiology/ American Heart Association Task Force on Practice Guidelines. Circulation *106*(14):1883–1892.

Gledhill N, Jamnik VK [1992]. Characterization of the physical demands of firefighting. Can J Spt Sci *17*(3):207–213.

Greenland P, Alpert JS, Beller GA, Benjamin EJ, Budoff MJ, Fayad ZA, Foster E, Hlatky MA, Hodgson JM, Kushner FG, Lauer MS, Shaw LJ, Smith SC Jr., Taylor AJ, Weintraub WS, Wenger NK [2010]. 2010 ACCF/AHA guideline for assessment of cardiovascular risk in asymptomatic adults: a report of the American College of Cardiology Foundation/ American Heart Association Task Force on Practice Guidelines. Circulation *122*(25):e584–e636.

Gurubhagavatula I, Maislin G, Nkwuo JE, Pack AL [2004]. Occupational screening for obstructive sleep apnea in commercial drivers. Am J Respir Crit Card Med *170*(4):371–376.

IAFF, IAFC [2008]. The fire service joint labor management wellness/fitness initiative. 3rd ed. Washington, DC: International Association of Fire Fighters, International Association of Fire Chiefs.

Kales SN, Soteriades ES, Christoudias SG, Christiani DC [2003]. Firefighters and on-duty deaths from coronary heart disease: a case control study. Environ health: a global access science source. 2:14. [http://www.ehjournal.net/content/2/1/14]. Date accessed: July 2014.

Kales SN, Soteriades ES, Christophi CA, Christiani DC [2007]. Emergency duties and deaths from heart disease among fire fighters in the United States. N Engl J Med *356*(12):1207–1215.

Kuehl KS, Elliot DL, Goldberg L, Moe EL, Perrier E, Smith J [2013]. Economic benefit of the PHLAME wellness programme on firefighter injury. Occ Med *63*(3):203–209.

Levy D, Garrison RJ, Savage DD, Kannel WB, Castelli WP [1990]. Prognostic implications of echocardiographically determined left ventricular mass in the Framingham Heart Study. N Engl J Med *323*(24):1706–1707.

Libby P [2013]. Mechanisms of acute coronary syndromes and their implications for therapy. N Engl J Med *368*(21):2004–2013.

References (cont.)

Meyerburg RJ, Castellanos A [2008]. Cardiovascular collapse, cardiac arrest, and sudden cardiac death. In: Fauci AS, Braunwald E, Kasper DL, Hauser SL, Longo DL, Jameson JL, Loscalzo J, eds. Harrison's principles of internal medicine. 17th ed. New York: McGraw-Hill, pp. 1707–1713.

Mittleman MA, Maclure M, Tofler GH, Sherwood JB, Goldberg RJ, Muller JE [1993]. Triggering of acute myocardial infarction by heavy physical exertion. N Engl J Med *329*(23):1677–1683.

NFPA [2008]. Standard on health-related fitness programs for fire fighters. Quincy, MA: National Fire Protection Association. NFPA 1583.

NFPA [2013a]. Standard on comprehensive occupational medical program for fire departments. Quincy, MA: National Fire Protection Association. NFPA 1582.

NFPA [2013b]. Standard on fire department occupational safety and health program. Quincy, MA: National Fire Protection Association. NFPA 1500.

NHLBI [2012]. Who is at risk for coronary artery disease? National Heart, Lung, and Blood Institute. [http://www.nhlbi.nih.gov/health/health-topics/topics/cad/atrisk.html]. Date accessed: July 2014.

NIOSH [2007]. NIOSH alert: preventing fire fighter fatalities due to heart attacks and other sudden cardiovascular events. [http://www.cdc.gov/niosh/docs/2007-133/]. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2007-133.

NOAA [2013]. Quality controlled local climatological data: (final). Hourly observations table, Wilkes-Barre/Scranton International Airport November 20, 2013. [http://cdo.ncdc.noaa.gov/qclcd/QCLCD]. Date accessed: July 2014.

OSHA (Occupational Safety and Health Administration) [2013]. State occupational safety and health plans. [http://www.osha.gov/dcsp/osp/index.html]. Date accessed: July 2014.

Pelletier KR [2009]. A review and analysis of the clinical and cost–effectiveness studies of comprehensive health promotion and disease management programs at the worksite: update VII 2004–2008. J Occup Environ Med *51*(7):822–837.

Poston WSC, Haddock CK, Jahnke SA, Jitnarin N, Day RS [2013]. An examination of the benefits of health promotion programs for the national fire service. BMC Pub Health *13*(1):805–819.

Schneider EL [2010]. Firefighter fitness: a health and wellness guide. New York: Nova Science Publishers.

Siegel RJ [1997]. Myocardial hypertrophy. In: Bloom S, ed. Diagnostic criteria for cardiovascular pathology acquired diseases. Philadelphia, PA: Lippencott-Raven, pp. 55–57.

References (cont.)

Somers VK, White DP, Amin R, Abraham WT, Costa F, Culebras A, Daniels S, Floras JS, Hunt CE, Olson LJ, Pickering TG, Russell R, Woo M, Young T [2008]. Sleep apnea and cardiovascular disease: an American Heart Association/American College of Cardiology Foundation scientific statement from the American Heart Association Council for High Blood Pressure Research Professional Education Committee, Council on Clinical Cardiology, Stroke Council, and Council on Cardiovascular Nursing Council. J Amer Coll Cardiol *52*(8):686–717.

USFA [2009]. Health and wellness guide for the volunteer fire and emergency services. Emmitsburg, MD: Federal Emergency Management Agency; United States Fire Administration. Publication No. FA-321.

Womack JW, Humbarger CD, Green JS, Crouse SF [2005]. Coronary artery disease risk factors in firefighters: effectiveness of a one-year voluntary health and wellness program. Med Sci Sports Exerc *37*(5):S385.

Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component in Cincinnati, Ohio. Mr. Tommy Baldwin (MS) led the investigation and co-authored the report. Mr. Baldwin is a Safety and Occupational Health Specialist, a National Association of Fire Investigators (NAFI) Certified Fire and Explosion Investigator, an International Fire Service Accreditation Congress (IFSAC) Certified Fire Officer I, and a former Fire Chief and Emergency Medical Technician. Accompanying Mr. Baldwin was Dr. Judith Eisenberg (MD, MS). Dr. Eisenberg is a physician with the NIOSH Health Hazard Evaluation Program. Dr. Thomas Hales (MD, MPH) provided medical consultation and co-authored the report. Dr. Hales is a member of the NFPA Technical Committee on Occupational Safety and Heath, and Vice-Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).

Appendix A

Autopsy Findings

- Coronary artery atherosclerosis
  - Focal plaque rupture and intraluminal thrombus (blood clot) in the right coronary artery
  - 90% narrowing of the left anterior descending coronary artery
  - 90% focal narrowing of the circumflex coronary artery
  - 60% focal narrowing of the right coronary artery
  - 45% focal narrowing of the left main coronary artery
- Hypertensive heart disease
  - Cardiomegaly (enlarged heart; heart weighed 645 grams [g]; predicted normal weight is 453 g [ranges between 343 g and 598 g as a function of sex, age, and body weight]) [Silver and Silver 2001]
  - Biventricular hypertrophy
    - Left ventricle thickened (3.0 centimeter [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]
    - Concentric hypertrophy in right ventricle [Armstrong and Feigenbaum 2001]
  - Myocardial fibrosis (remote infarction) in posterior wall of left ventricle
- Focally calcific mitral and aortic valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)

References

Armstrong WF, Feigenbaum H [2001]. Echocardiography. In: Braunwald E, Zipes DP, Libby P, eds. Heart disease: a text of cardiovascular medicine. 6th ed. Vol. 1. Philadelphia, PA: W.B. Saunders Company, p. 167.

Colucci WS, Braunwald E [1997]. Pathophysiology of heart failure. In: Braunwald, ed. Heart disease. 5th ed. Philadelphia, PA: W.B. Saunders Company, p. 401.

Connolly HM, Oh JK [2012]. Echocardiography. In: Bonow RO, Mann DL, Zipes DP, Libby P, Braunwald E, eds. Heart disease: a text of cardiovascular medicine. 9th ed. Vol. 1. Philadelphia, PA: Elsevier Saunders, p. 216.

Silver MM, Silver MD [2001]. Examination of the heart and of cardiovascular specimens in surgical pathology. In: Silver MD, Gotlieb AI, Schoen FJ, eds. Cardiovascular pathology. 3rd ed. Philadelphia, PA: Churchill Livingstone, pp. 8–9.