



# Death in the line of duty...

**NIOSH**  
Fire Fighter Fatality Investigation  
and Prevention Program

A summary of a NIOSH fire fighter fatality investigation

January, 2013

## **Fire Fighter Suffers Fatal Heart Attack While Performing Driver/Operator Duties at a Motor Vehicle Crash – South Carolina**

### **Executive Summary**

On January 9, 2012, a 63-year-old male volunteer fire fighter (“the FF”) was dispatched at 0633 hours to a motor vehicle crash involving three vehicles with possible entrapment. At the scene, the FF operated the pumper as crew members utilized a handline to wash the fuel away from the vehicles. A short while later the Chief found the FF collapsed on the elevated pump platform. Crew members pulled the FF from the pumper to the ground, assessed him, and found him to be unresponsive, not breathing, and without a pulse. An ambulance was requested as cardiopulmonary resuscitation (CPR) was begun (0705 hours). A paramedic ambulance arrived 15 minutes later and began advanced life support. The FF was transported to the local hospital’s emergency department (ED) arriving at 0749 hours. Inside the ED, cardiac resuscitation efforts continued for an additional 6 minutes when the FF was pronounced dead.

The death certificate, completed by the county coroner, listed “acute myocardial infarction due to thrombosis of the left main coronary artery due to atherosclerotic coronary artery disease with cardiomegaly (830) grams” as the cause of death. The autopsy report, completed by a pathologist, listed “acute myocardial infarction” as the cause of death and “strenuous activity during rescue procedures” as a contributing factor. Given the FF’s history of underlying coronary heart disease (CHD), NIOSH investigators concluded that the physical stress

of responding to the call and performing driver/operator duties triggered his heart attack and subsequent sudden cardiac death.

NIOSH investigators offer the following recommendations to address safety and health issues and prevent similar incidents in the future.

***Provide preplacement medical evaluations to all fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.***

***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.***

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

***Perform an annual physical performance (physical ability) evaluation for all members.***

## ***Fire Fighter Suffers Fatal Heart Attack While Performing Driver/Operator Duties at a Motor Vehicle Crash – South Carolina***

---

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH “Fire Fighter Fatality Investigation and Prevention Program” which examines line-of-duty-deaths or on duty deaths of fire fighters to assist fire departments, fire fighters, the fire service and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with State or Federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency’s reports do not name the victim, the fire department or those interviewed. The NIOSH report’s summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency’s recommendations and is not intended to be definitive for purposes of determining any claim or benefit. For further information, visit the program website at [www.cdc.gov/niosh/fire](http://www.cdc.gov/niosh/fire) or call toll free 1-800-CDC-INFO (1-800-232-4636).

## **Fire Fighter Suffers Fatal Heart Attack While Performing Driver/Operator Duties at a Motor Vehicle Crash – South Carolina**

### **Introduction & Methods**

On January 9, 2012, a 63-year-old male volunteer fire fighter suffered a heart attack and subsequent sudden cardiac death while performing driver/operator duties at a motor vehicle crash. NIOSH contacted the affected fire department (FD) on January 12, 2012, to gather additional information, and on July 12, 2012, to initiate the investigation. On July 30, 2012, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Prevention and Investigation Program conducted an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- County career Fire Chief
- Volunteer Fire Chief
- FD medical evaluation coordinator
- Primary care physician
- FF's spouse and family

NIOSH personnel reviewed the following documents:

- FD standard operating procedures
- FD incident report
- Ambulance report
- Hospital ED records
- Death certificate
- Autopsy report
- Primary care physician records

### **Investigative Results**

**Incident.** On January 9, 2012, the FD was dispatched to a motor vehicle crash at 0633 hours involving three vehicles with possible entrapment. Engine 2-1 (the FF and the Chief) responded at 0638 hours as 12 additional FD personnel responded directly to the scene. Upon arrival, it was determined there was no entrapment, but one patient needed transport to the hospital's ED. One of the crash vehicles was leaking gasoline and crew members pulled a booster line to wet the area and

### **Investigative Results (cont.)**

wash the gasoline away from the vehicles. The FF climbed onto the elevated pump operator platform and operated the pump, adjusting the pressure as necessary. At 0704 hours, the Chief motioned to the FF to adjust the pressure, but he did not see the FF. As he walked to the engine, the Chief saw the FF collapsed on the pump platform and alerted nearby crew members.

Crewmembers pulled the FF off the pumper and found him unresponsive, not breathing, and without a pulse. Crew members removed the FF's turnout coat and began CPR as an ambulance was requested (0705 hours). The ambulance, staffed with two paramedics, arrived on scene at 0720 hours and found the FF unresponsive with CPR in progress. Advanced life support began which included cardiac monitoring, intravenous line placement, and intubation. The cardiac monitor revealed asystole (no heart beat), cardiac resuscitation medications were administered, and intubation tube placement was verified by capnography [Neumar et al. 2010]. The ambulance departed the scene at 0731 hours en route to the hospital's ED and arrived at 0749 hours. Inside the ED, cardiac resuscitation efforts continued without success until 0755 hours when the FF was pronounced dead and resuscitation efforts were stopped.

**Medical Findings.** The death certificate, completed by the county coroner, listed "acute myocardial infarction due to thrombosis of the left main coronary artery due to atherosclerotic coronary artery disease with cardiomegaly (830) grams" as the cause of death. The autopsy report, completed by a pathologist, listed "acute myocardial infarction" as the cause of death and "strenuous activity during rescue procedures" as a contributing factor. Additional autopsy findings included a

## **Fire Fighter Suffers Fatal Heart Attack While Performing Driver/Operator Duties at a Motor Vehicle Crash – South Carolina**

### **Investigative Results (cont.)**

thrombosis (blood clot) in the left main coronary artery, a remote (old) myocardial infarction with previous stents placed in the left anterior descending coronary artery, cardiomegaly (enlarged heart), symmetrical hypertrophy (dilatation) of the left and right ventricles, and degeneration of the mitral valve and the aortic valve. Other pertinent autopsy findings are listed in Appendix A.

The FF had multiple medical problems. These included:

- Coronary heart disease (CHD): a remote (old) heart attack with angioplasty and stent placement in his left anterior descending coronary artery in 2011;
- Hypertension: high blood pressure readings noted since 1980, poorly controlled with complications of concentric left ventricular hypertrophy by echocardiogram in 2011;
- Type II diabetes mellitus: high blood sugars (glucose ranged from 105-191 milligram per deciliter (mg/dL), hemoglobin A1c of 7.9) first noted in 1987 with treatment beginning in 2011 with an oral agent;
- Deep vein thrombosis: complicated with a large pulmonary embolus in 2011 placed on coumadin (blood thinner);
- Hyperlipidemia and hypertriglyceridemia: first noted in the 1980s treated with diet and exercise in the 1990s followed by statin treatment in 2011.
- Sleep apnea and obesity: He was 78 inches tall and weighed 370 pounds, giving him a body mass index of 42.8 kilograms per meters squared. A body mass index > 30.0 kilograms per meter squared is considered obese [CDC 2011].

As part of the FD annual medical evaluation, the FF had a “Graded Exercise Stress Test (GXT) - Bicycle Ergometer” test in 1997, 2000 - 2003, 2006, 2008, and 2009. The FD contractor performing this test had subjects pedal on the bicycle at 50 revolutions per minute. Pedal resistance was increased by 0.5 kilogram (kg) each minute until the subjects reached 85% of their maximal age-predicted heart rate, at which point the test was stopped. The contractor used a 12-lead electrocardiogram (EKG) to monitor the subjects’ heart rate, and once the test was completed, to look for signs of cardiac ischemia. If ischemia was found, subjects were referred to their primary care physician for follow-up. In addition to pulse, blood pressure was measured every minute during the test and for 5 minutes during the test recovery phase. The FF’s last GXT was in 2009 and he exercised for 6 minutes achieving 82% of his maximal estimated heart rate and an exercise capacity of 21.5 milliliters of oxygen per kilogram per minute [6.1 metabolic equivalents (METS)]. He was declared “unclear” for full duty due to “ST-segment depression [in leads] II, III, AVF, V2 – V6, suggestive of CAD [coronary heart disease]” but continued volunteering at the FD without medical clearance.

The FF’s last annual FD medical evaluation was in October 2011 at which time his medications included an antihypertensive (beta-blocker), a diuretic, a blood thinner, a statin (cholesterol-lowering), an oral antihyperglycemic, and allopurinol (gout). He did not perform an exercise stress test on the bicycle ergometer. The testing contractor declared the FF “unclear” for duty as a fire fighter. However the next day his personal physician cleared him for full duty.

## **Fire Fighter Suffers Fatal Heart Attack While Performing Driver/Operator Duties at a Motor Vehicle Crash – South Carolina**

### **Description of the Fire Department**

At the time of the NIOSH investigation, the FD consisted of one fire station with 28 volunteer uniformed personnel. It served 3,500 residents in a geographic area of 10 square miles. The FD is part of a county fire department system comprised of 28 fire stations and over 850 volunteer fire fighters.

**Membership and Training.** The FD requires new fire fighter applicants to be 18 years of age, have a valid state driver's license, pass a background check, and be voted on by the membership. The new member receives training at the fire station and at regional and State fire schools. State fire fighter certification is voluntary. There is no State mandatory annual refresher training. The FF was certified as a Fire Fighter 2, Fire Officer, Fire Investigator, Wildland Fire Fighter, Driver/Operator, and in hazardous materials. He had 47 years of fire fighting experience, including 22 years serving as Fire Chief.

**Preplacement and Annual Medical Evaluations.** No preplacement medical evaluation is required, however an annual medical evaluation is required. The components of the annual medical evaluation include the following:

- Complete medical history
- Physical examination (including vital signs)
- Complete blood count with lipid panel
- Pulmonary function test
- Audiogram
- Vision screen
- Urinalysis
- Resting EKG
- Submaximal cycle ergometer test (described in detail on page 4)

These evaluations are performed by a contract mobile medical clinic. Following the evaluation, a physician traveling with the clinic determines medical clearance for respirator use and fire fighting duties, and forwards this decision to the FD.

An annual self-contained breathing apparatus facepiece fit test is required. For members injured on duty or who are ill and cannot respond to calls, medical clearance is not required for return to duty.

**Health and Wellness Programs.** The FD does not have a wellness/fitness program, and exercise equipment is not available in their fire station. No annual physical ability test is required.

### **Discussion**

**Atherosclerotic Coronary Heart Disease (CHD).** In the United States, CHD is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development include three non-modifiable factors (age older than 45, male gender, and family history of CHD) and five modifiable factors (smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes) [AHA 2012; NHLBI 2012]. The FF had known CHD with a previous heart attack and stent placement. He had four of five modifiable CHD risk factors (high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes) at the time of his death.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2008]. However, the growth of

## **Fire Fighter Suffers Fatal Heart Attack While Performing Driver/Operator Duties at a Motor Vehicle Crash – South Carolina**

### **Discussion (cont.)**

these plaques probably occurs in a nonlinear, often abrupt fashion [Shah 1997]. Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply [Fuster et al. 1992]. This sudden blockage is primarily due to blood clots (thromboses) forming on top of atherosclerotic plaques. Establishing a recent (acute) heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes, or coronary artery thrombus. In this case, a thrombus was identified in his left main coronary artery confirming an acute heart attack (myocardial infarction).

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks and sudden cardiac death [Albert et al. 2000]. Heart attacks in fire fighters 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 FF had responded to the alarm and performed driver/operator activities while wearing full turnout gear (no SCBA). These activities expended about 6 METs, which is considered moderate physical activity [Gle-dhill and Jamnik 1992; Ainsworth et al. 2011].

### **Occupational Medical Standards for Structural Fire Fighters.**

To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the NFPA developed NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments [NFPA 2007a]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. The FF had five known conditions relevant to medical clearance: CHD, diabetes mellitus, deep

vein thrombosis, and two medications (blood thinner and beta blocker).

**CHD.** The FF had CHD as evidenced by his remote (old) heart attack and stent placement. He had been unable to reduce or eliminate his four modifiable CHD risk factors. According to NFPA 1582, members with CAD should be precluded from unrestricted fire fighting because of the risk of sudden incapacitation [NFPA 2007a]. The criteria include the following:

- 1) Current angina pectoris even if relieved by medication
- 2) Persistent significant stenosis in any coronary artery (>70% lumen diameter narrowing) following treatment
- 3) Lower than normal left ventricular ejection fraction as measured by radionuclide scan, contrast ventriculography, or echocardiography
- 4) Maximal exercise tolerance of < 42 milliliters of oxygen per minute per kilogram or < 12 metabolic equivalents (METs)
- 5) Exercise-induced ischemia or ventricular arrhythmias observed by radionuclide stress test during an evaluation reaching at least a 12-METs workload
- 6) History of myocardial infarction, angina, or coronary artery disease with persistence of modifiable risk factor(s) for acute coronary plaque rupture (e.g., tobacco use, hypertension despite treatment or hypercholesterolemia with cholesterol  $\geq$  180 or low density lipoproteins  $\geq$  100 despite treatment, or glycosylated hemoglobin  $>$  7 despite exercise and/or weight reduction)

The FF did not meet items #3, #4, #5, and #6 and, according to NFPA 1582, should not have been cleared for duty in 2011.

## **Fire Fighter Suffers Fatal Heart Attack While Performing Driver/Operator Duties at a Motor Vehicle Crash – South Carolina**

### **Discussion (cont.)**

**Diabetes Mellitus.** NFPA 1582 provides guidance for fire department physicians regarding fire fighters with diabetes [NFPA 2007a]. The standard states that fire fighters with diabetes mellitus that is controlled by diet, exercise, or oral hypoglycemic agents should be restricted from duty unless the member meets all of the following criteria:

- 1) If on oral hypoglycemic agents, has had no episodes of severe hypoglycemia (defined as requiring assistance of another in the preceding year)
- 2) Has achieved a stable blood glucose as evidenced by HA1C level less than 8 during the prior 3-month period
- 3) Has normal renal function on the basis of a calculated creatinine clearance greater than 60 milliliters per minute and absence of proteinuria
- 4) Has a dilated retinal exam by a qualified ophthalmologist or optometrist that shows no higher grade of diabetic retinopathy than microaneurysms
- 5) Has no autonomic or peripheral neuropathy
- 6) Has normal cardiac function without evidence of myocardial ischemia on cardiac stress testing (to at least 12 METs) by EKG and cardiac imaging [NFPA 2007a].

The FF was prescribed an oral diabetic medication and was asymptomatic. The FF met items #1-3 but he was not tested for items #4 and #5, and did not meet the criteria for item #6 since at least 2002. Thus, he should have been restricted from duty.

#### **Deep Vein Thrombosis and Anticoagulation**

**Therapy.** The FF was diagnosed with deep vein thrombosis in June 2011 and treated with full dose anticoagulation (coumadin). NFPA 1582 considers that deep venous thrombosis and full-dose anticoagulation compromise a member's ability to safely perform fire fighting tasks, wear encapsulating

fire protective ensemble, climb six or more flights of stairs while wearing fire protective ensemble, advance water-filled hoselines up to 2½-inches, and meet unpredictable emergency requirements for prolonged periods of extreme physical exertion [NFPA 2007a]. Therefore, according to NFPA 1582, the FF should have been restricted from fire fighting duties.

**Beta Blocker Therapy.** The FF was diagnosed with hypertension and treated with a beta blocker in 2011. The NFPA considers use of beta blockers to potentially preclude safely wearing the fire protective ensemble and safely climbing ladders, operating from heights, walking or crawling in the dark along narrow and uneven surfaces, and operating near electrical power lines or other hazards because of the risk for dehydration, electrolyte disorders, lethargy, and disequilibrium [NFPA 2007a].

Given the FF's CHD, hyperglycemia, full-dose anticoagulation treatment, and beta blocker medication, he should have been restricted from full fire suppression duties.

**Left Ventricular Hypertrophy/Cardiomegaly.** The FF was diagnosed with left ventricular hypertrophy and cardiomegaly in 2011 during an echocardiogram, and in 2012 during his autopsy. Both these conditions independently increase the risk of sudden cardiac death [Levy et al. 1990]. Hypertrophy of the heart's left ventricle and cardiomegaly are relatively common findings among individuals with hypertension, a heart valve problem, or CHD. The FF had all three of these conditions.

## **Fire Fighter Suffers Fatal Heart Attack While Performing Driver/Operator Duties at a Motor Vehicle Crash – South Carolina**

### **Recommendations**

NIOSH investigators offer the following recommendations to address safety and health issues and prevent similar incidents in the future.

#### ***Recommendation #1: Provide preplacement medical evaluations to all fire fighters 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 2007a; IAFF, IAFC 2008]. 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. To ensure improved health and safety of candidates and members, and to ensure continuity of medical evaluations, it is recommended the FD comply with this recommendation, particularly the section addressing CHD issues. Although the FF had a submaximal cycle ergometer test to measure his aerobic capacity, this test is not the same as the diagnostic exercise stress test recommended by NFPA 1582 or the ACC/AHA [Gibbons et al. 2002; NFPA 2007a]. However, the FD is not legally required to follow the NFPA standard or the IAFF/IAFC initiative. Applying this recommendation involves economic repercussions and may be particularly difficult for smaller fire departments to implement.

To overcome the financial obstacle of medical evaluations, the FD 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 EKG). 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 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 FD, city, or state. Sharing the financial responsibility for these evaluations between fire fighters, the FD, the city, the state, and physician volunteers may reduce the negative financial impact on recruiting and retaining needed fire fighters.

#### ***Recommendation #2: 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 [NFPA 2007a; IAFF, IAFC 2008]. According to these guidelines, 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. The physician should review job descriptions and essential job tasks required for all FD positions and ranks to understand the physiological and psychological demands of fire fighters and the environmental conditions under which they

## **Fire Fighter Suffers Fatal Heart Attack While Performing Driver/Operator Duties at a Motor Vehicle Crash – South Carolina**

### **Recommendations (cont.)**

must perform, as well as the personal protective equipment they must wear during various types of emergency operations. According to NFPA 1582, the FF had three conditions (CHD, anticoagulation therapy, and beta blocker medication) that should have precluded him from unrestricted duty [NFPA 2007a]. In 2009 and again in 2011, the FD's annual medical evaluation conducted by the contract mobile medical clinic determined the FF was “unclear” for full duty. In 2009, the FF continued volunteering at the FD without medical clearance and in 2011 the FF's personal physician cleared him for full duty.

#### ***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 National Volunteer Fire Council Health and Wellness Guide, and in Firefighter Fitness: A Health and Wellness Guide [USFA 2004; IAFF, IAFC 2008; NFPA 2008; 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 CHD 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 re-

ported 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 2007]. The FD does not have a wellness/fitness program. Given the FD's structure, the National Volunteer Fire Council program would be very helpful [USFA 2004]. NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program.

#### ***Recommendation #4: Perform an annual physical performance (physical ability) evaluation for all members.***

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires the FD to develop physical performance requirements for candidates and members who engage in emergency operations [NFPA 2007b]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2007b]. This could be incorporated into the annual task-level training program.

## **Fire Fighter Suffers Fatal Heart Attack While Performing Driver/Operator Duties at a Motor Vehicle Crash – South Carolina**

### **References**

- AHA (American Heart Association) [2012]. 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](http://www.heart.org/HEARTORG/Conditions/HeartAttack/UnderstandYourRiskofHeartAttack/Understand-Your-Risk-of-Heart-Attack_UCM_002040_Article.jsp)]. Date accessed: September 2012.
- 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.
- Aldana SG [2001]. Financial impact of health promotion programs: a comprehensive review of the literature. *Am J Health Promot* 15(5):296–320.
- 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.
- CDC (Centers for Disease Control and Prevention) [2011]. Assessing your weight. [<http://www.cdc.gov/healthyweight/assessing/index.html>]. Date accessed: September 2012.
- 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.
- Fuster V, Badimon L, Badimon JJ, Chesebro JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. *N Engl J Med* 326(4):242–250.
- 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.
- 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: September 2012.
- 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.

## **Fire Fighter Suffers Fatal Heart Attack While Performing Driver/Operator Duties at a Motor Vehicle Crash – South Carolina**

### **References (cont.)**

- Kuehl K [2007]. Economic impact of the wellness fitness initiative. Presentation at the 2007 John P. Redmond Symposium in Chicago, IL on October 23, 2007.
- 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 [2008]. The pathogenesis, prevention, and treatment of atherosclerosis. 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. 1501–1509.
- 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.
- NFPA [2007a]. Standard on comprehensive occupational medical program for fire departments. Quincy, MA: National Fire Protection Association. NFPA 1582.
- NFPA [2007b]. Standard on fire department occupational safety and health program. Quincy, MA: National Fire Protection Association. NFPA 1500.
- NFPA [2008]. Standard on health-related fitness programs for fire fighters. Quincy, MA: National Fire Protection Association. NFPA 1583.
- NHLBI [2012]. Who is at risk for coronary heart disease? National Heart, Lung, and Blood Institute. [<http://www.nhlbi.nih.gov/health/health-topics/topics/cad/atrisk.html>]. Date accessed: September 2012.
- 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.
- Neumar RW, Otto CW, Link MS, Kronick SL, Shuster M, Callaway CW, Kudenchuk PJ, Ornato JP, McNally B, Silvers SM, Passman RS, White RD, Hess EP, Tang W, Davis D, Sinz E, Morrison LJ [2010]. Part 8: Adult advanced cardiovascular life support. 2010 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Dallas, TX: American Heart Association.
- Schneider EL [2010]. Firefighter fitness: a health and wellness guide. New York: Nova Science Publishers.
- Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. *Clin Cardiol* 20(11 Suppl 2):II-38–44.
- Stein AD, Shakour SK, Zuidema RA [2000]. Financial incentives, participation in employer sponsored health promotion, and changes in employee health and productivity: HealthPlus health quotient program. *J Occup Environ Med* 42(12):1148–1155.

## **Fire Fighter Suffers Fatal Heart Attack While Performing Driver/Operator Duties at a Motor Vehicle Crash – South Carolina**

### **References (cont.)**

USPSTF [2004]. U.S. Prevention Services Task Force. Screening for coronary heart disease: Recommendation Statement. Ann Intern Med 140(7):569–572.

Womack JW, Hamburger 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), 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, led the investigation and co-authored the report. Dr. Thomas Hales (MD, MPH), 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), provided medical consultation and co-authored the report.

## ***Fire Fighter Suffers Fatal Heart Attack While Performing Driver/Operator Duties at a Motor Vehicle Crash – South Carolina***

## Appendix A

## Autopsy Findings

- Hypertensive heart disease
    - Cardiomegaly (enlarged heart; heart weighed 830 grams [g]; predicted normal weight is 509 g [ranges between 386 g and 674 g as a function of sex, age, and body weight]) [Silver and Silver 2001]
    - Biventricular hypertrophy
      - Left ventricle thickened (2.8 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]
      - Right ventricle thickened (1.0 cm)
        - Normal by echocardiography 0.7–2.3 cm [Armstrong and Feigenbaum 2001]
  - Coronary artery atherosclerosis
    - Thrombus (blood clot) in the left main coronary artery
    - Moderate to severe (70%) focal narrowing of the left anterior descending coronary artery with stent
    - Moderate to severe (70%) focal narrowing of the right coronary artery
    - Moderate (60%) focal narrowing of the circumflex coronary artery
    - Fibrous scar in the posterior left ventricular wall (old heart attack)
    - Mitral and aortic valve degeneration with fibromyxoid changes

## References

Armstrong WF, Feigenbaum H [2001]. Echocardiography. In: Braunwald E, Zipes DP, Libby P, eds. Heart disease: a text of cardiovascular medicine. 6<sup>th</sup> 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.