2010
27

Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

*A summary of a NIOSH fire fighter fatality investigation* *September, 2012*

# Driver/Operator Suffers Fatal Heart Attack While Responding to Structure Fire – North Carolina

## Executive Summary

On January 31, 2009, a 58-year-old volunteer fire fighter [also the Driver/Operator (D/O) for this incident] responded to a structure fire. While driving the engine/tanker to the fire scene, the D/O developed severe chest pain. Upon arrival at the fire scene, the D/O was evaluated by a paramedic who emergently arranged ambulance transport. During transport an acute myocardial infarction (heart attack) was diagnosed by electrocardiogram (ECG) and upon arrival at the local hospital's emergency department (ED), the D/O received emergent thrombolytic therapy. With no improvement in his clinical condition, the D/O was airlifted to a larger hospital for emergency cardiac catheterization. During the cardiac catheterization the D/O suffered a cardiac arrest and resuscitation efforts were unsuccessful. The death certificate, completed by the treating cardiologist, listed "cardiogenic shock" as the cause of death with "acute myocardial infarction" as a contributing condition. No autopsy was performed. The NIOSH investigators concluded the physiologic demands associated with the emergency response to a structure fire probably triggered the D/O's heart attack and subsequent cardiac death.

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

***Provide mandatory pre-placement and annual medical evaluations to all fire fighters, consistent with the requirements of National Fire Protection Association (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.***

***Develop a job-related, comprehensive wellness/fitness program for fire fighters.***

***Educate fire fighters on the signs and symptoms of a heart attack.***

***Perform a pre-placement and annual physical performance (physical ability) evaluation for all members.***

***Provide fire fighters with medical clearance to wear self-contained breathing apparatus as part of a Fire Department medical evaluation program.***

# *Driver/Operator Suffers Fatal Heart Attack While Responding to Structure Fire – North Carolina*

# *Driver/Operator Suffers Fatal Heart Attack While Responding to Structure Fire – North Carolina*

## Introduction & Methods

On January 31, 2009, a 58-year-old male volunteer (paid-on-call) fire fighter who was the D/O of an engine tanker developed angina while responding to a residential structure fire. Despite treatment for an acute myocardial infarction (MI) at a local hospital ED and airlifting to a cardiac referral hospital, the D/O died. NIOSH was notified of this fatality on February 3, 2009 by the United States Fire Administration. NIOSH contacted the affected fire department (FD) to gather additional information on July 14, 2010 to initiate the investigation. On August 9, 2010, a contractor from the NIOSH Fire Fighter Fatality Investigation Team traveled to North Carolina to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- Deputy Chief (both on scene at incident)
- Firefighter-EMT and paramedic crew members who treated the D/O at the incident scene
- D/O's spouse

NIOSH personnel reviewed the following documents:

- FD training records
- FD policies and operating guidelines
- FD annual report for 2009
- National Fire Incident Reporting System (NFIRS) report
- Chief and crew statements
- Emergency medical service (EMS) incident report
- Hospital ED records
- Transfer hospital records
- Death certificate
- Primary care provider medical records

## Investigative Results

***Incident.*** On January 31, 2009, at 2329 hours, the FD was dispatched to a structure fire. Weather conditions at the time of dispatch were 33.8 degrees Fahrenheit with no winds. Five units from the FD responded [Engine (E)-2401, E-2502, Engine Tanker (ET)-2406, ET-4706 (the D/O's unit) and Rescue 2414], with mutual aid units staging nearby. E-2401, and ET-2406 arrived at 2339 hours and pulled two 1¾-inch attack lines to the front door. Crews entered the house and extinguished a dryer fire in a storage/washroom area at the corner of sides B/C. At 2349 hours, ET-4706 arrived on scene, with the D/O and another fire fighter. The house was being ventilated throughout using positive pressure ventilation, and salvage and overhaul were beginning.

While driving ET-4706 to the fire scene, the D/O looked winded to the fire fighter riding with him. When asked if he was okay, the D/O mentioned sprinting about 100 yards from his home to his personal vehicle while responding to the station. He also mentioned jumping out to close the bay door while leaving the station. During the response, the D/O had to slam on the brakes to avoid hitting several deer who had jumped in front of the engine. While driving the D/O stated he didn't feel well several times, and upon arrival at the fire scene began clutching his chest.

The other fire fighter jumped out of the truck and located a fire fighter-paramedic to evaluate the D/O. The paramedic noted the D/O was pale and leaning over the steering wheel, and asked the D/O to get out of the truck for evaluation. Initial vital signs were normal, but he was diaphoretic with severe substernal chest pressure that had started about halfway through the drive to the fire scene. The paramedic called for emergency

# *Driver/Operator Suffers Fatal Heart Attack While Responding to Structure Fire – North Carolina*

## Investigative Results (cont.)

transport at about 0007 hours (according to EMS records) and provided oxygen via nasal cannula. The ambulance arrived at 0014 hours and the paramedic walked the D/O to the ambulance, joining the EMS team who transported the D/O to the local hospital's ED.

During transport to LH, a local hospital, a second paramedic elicited the history that the D/O had not been feeling well for a few days, and confirmed that the chest pain began while en route to the fire. Later, the D/O's family told cardiologists that he felt fatigued, and had been experiencing bilateral shoulder and abdominal pain for a few days.

En route to the hospital a 12-lead electrocardiogram (ECG) at 0017 hours showed ST segment elevations consistent with a heart attack [ST Elevation Myocardial Infarction (STEMI)] involving the inferior wall of the heart. At this time the D/O was hypotensive (low blood pressure, with systolic reading of 50-60 millimeters of mercury (mm Hg), bradycardic (slow heart rate, at 48-54, beats per minute), with clear lungs. An intravenous fluid bolus was given with no change in his blood pressure, and the D/O also received oral aspirin. An ECG with right sided leads was done at 0028 hours and showed findings consistent with a right ventricular infarction. These two ECGs were transmitted and reviewed by ED physicians. The paramedics requested approval from the ED to administer thrombolytic (clot-dissolving) therapy in the field but this request was denied until the D/O could be evaluated by the physicians in the ED. The ambulance paramedics considered proceeding directly to a percutaneous coronary intervention (PCI)-capable hospital (a longer distance), but the D/O's mental status began to deteriorate so they continued to the ED, arriving at 0037 hours (approximately 55 minutes after the D/O's symptoms began). The paramedic called for air transport upon arrival at the ED, anticipating the need for emergent transfer to the PCI center (55 miles away).

In the ED, the D/O's initial blood pressure was 73/52 mm Hg, with a heart rate of 49. He was given medications to dissolve the clot and support his blood pressure. His 12-lead ECG developed a junctional rhythm and he remained bradycardic (suggesting involvement of a specific electrical control area of the heart).

Transfer to the cardiac PCI center was ordered at 0109 hours. The D/O was intubated immediately prior to transfer, at 0155, and was airlifted to the cardiac PCI center. He went into ventricular fibrillation (VF) arrest while en route, but was defibrillated successfully back into sinus bradycardia. Amiodarone (to prevent another VF arrest) was begun intravenously, and he arrived at the cardiac PCI center on amiodarone and dopamine (to support his blood pressure). He remained bradycardic with his HR between 30 and 60 beats per minute.

By 0250 hours he was receiving treatment at the PCI center. A temporary pacemaker was inserted through a central vein to stabilize his heart rate. His cardiac catheterization showed 100% occlusion of the proximal right coronary artery (RCA), which supplies the blood to the inferior wall and the right ventricle. The RCA was opened during the catheterization procedure, and a stent was placed to hold the artery open. After placement of this stent, a possible dissection flap was noted and a second stent was placed to keep the flap out of the lumen. Other findings during cardiac catheterization included evidence of heart failure (left ventricular ejection

# Driver/Operator Suffers Fatal Heart Attack While Responding to Structure Fire – North Carolina

## Investigative Results (cont.)

fraction of 20%) probably due to the STEMI and a dominant RCA that was occluded. When dye was injected into the left main coronary artery, his electrical rhythm went back into VF (his heart stopped pumping blood). He was defibrillated multiple times. Despite prolonged attempts at resuscitations including advanced cardiac life support (ACLS) medications and chest compressions, he did not regain pulses and was pronounced dead at 0415 hours on February 1, 2009.

***Medical Findings.*** The death certificate, completed by the cardiologist, listed the immediate cause of death as cardiogenic shock, with acute MI as the underlying cause. No autopsy was performed.

The D/O was 5'11" tall and weighed 180 lb, giving him a body mass index (BMI) of 24.9 (normal). The D/O's risk factors for coronary artery disease (CAD) included male gender, age over 45, elevated blood cholesterol level, family history of CAD, and smoking.

In 2003, the D/O had a physical exam during which mildly elevated cholesterol levels [218 milligram per deciliter (mg/dL), with LDL of 150 mg/dL] were noted. The primary care physician focused on smoking cessation, and prescribed bupropion, an atypical antidepressant often used for smoking cessation. A baby aspirin every day was also prescribed. The D/O did not return to any physicians because he did not have insurance after retiring from his previous job. He was not taking any medications at the time of the incident.

On the day of the incident, the D/O had been working strenuously, helping to refurbish a bulldozer by replacing the bed, hauling the unit, and sandblasting the truck.

## Description of the Fire Department

At the time of the NIOSH investigation, the volunteer FD consisted of two fire stations with 44 uniformed personnel that served a population of 7500 residents in a geographic area of 54 square miles. In 2009, the FD responded to 435 calls for medical assistance, and 174 calls for fire responses: 30 alarm activations, 41 structure fires, 6 vehicle fires, 15 brush fires, 2 other fires, 10 hazmat incidents, 13 motor vehicle crashes, 19 'other assistance', and 38 'other' calls.

***Membership and Training.*** The Fire Department requires new fire fighter applicants to be 18 years of age, and have a valid state driver's license. Applicants are voted on by the FD membership. The FD has a Junior Fire Fighter Program that allows junior fire fighters to train and perform support activities (ages 14-17).

The D/O had training in forestry (portable pumps, wildland fire chain saws, strategy and tactics), incident command (ICS-100, 200, 700), and various FD fire classes (forcible entry, rescue).

***Preplacement and Periodic Medical Evaluations.*** The FD does not currently require any pre-placement or annual medical evaluation for its members. Annual medical clearance to wear SCBA (as required by 29 CFR 1910.134) is not required.

***Health and Wellness Programs.*** The FD does not have a wellness/fitness program, but exercise (strength and aerobic) equipment is available at headquarters. Health maintenance programs are not available from the town. No annual physical ability or fitness test is required.

## Discussion

***Atherosclerotic Cardiovascular Disease.*** In the United States, atherosclerotic CAD is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for development of CAD include age older than 45, male gender, family history of CAD, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes [AHA 2012; NHLBI 2010]. This D/O had at least five CAD risk factors (age, male gender, smoking, family history, and high cholesterol).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2008]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion [Shah 1997]. Heart attacks typically occur when a complete blockage (occlusion) develops suddenly 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. The D/O had a thrombus in his right coronary artery, and an ECG and symptoms consistent with an acute MI.

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks and sudden cardiac death [Dahabreh and Paulus 2011]. 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]. Although the D/O worked strenuously earlier that day, he reported no symptoms suggestive of angina. During his initial response to the dispatch, the D/O sprinted approximately 100 yards expending an estimated 8 metabolic equivalents (METs) prior to arriving at the fire station. Eight METs is considered heavy physical activity [Mittleman et al. 1993]. Driving ET-4706 to the fire scene with the lights and siren on, and then having several deer jump in front of the apparatus would have exacerbated his "fight or flight" response. Both the physical exertion and the hormonally mediated fight or flight response increase the heart muscle's demand for oxygenated blood. When the coronary arteries are narrowed by CAD, they cannot supply enough blood to meet that demand. If the blood supply fails to meet the oxygen demand over minutes to hours, chest pain (angina) and heart attack (MI) can result. The loss of blood flow in his RCA, noted on the cardiac catheterization, had particularly severe consequences because it was his "dominant" artery, supplying a large proportion of this heart muscle. Patients who have this anatomy are at risk for the more severe complications of MI that were seen in this case. Given the D/O's CAD risk factors, underlying CAD, coronary artery anatomy, the stress of responding to the fire scene probably triggered his acute heart attack, cardiac arrest, and subsequent cardiac death.

***Treatment of STEMI.*** The treatment of these acute MIs requires early recognition followed by rapid, aggressive intervention. Treatment delays can be directly associated with decreased survival and poor prognosis [AHA 2005; Terkelsen et al. 2010]. Time delays can occur at any of the steps in the process: patient awareness of the symptoms of a heart attack, calling 9-1-1, appropriate medical dispatching, proper medical testing by EMS personnel, communication between EMS and the ED, regional diversion to PCI centers, and the hospital's "door-to-balloon" times. The fire service has an important role in many of these steps [IAFF 2007].

# *Driver/Operator Suffers Fatal Heart Attack While Responding to Structure Fire – North Carolina*

## Discussion (cont.)

In this case, the D/O did not seem to be aware his chest pain was cardiac in origin. His chest pain was a symptom of acute coronary syndrome which is associated with sudden incapacitation. Continuing to drive the engine/tanker with angina jeopardized not only the safety of the D/O and the accompanying FD member, but civilians traveling on the same road.

Cardiac PCI performed within 90 minutes of patient arrival is superior to thrombolytic drugs, but requires specialized centers and is not widely available [Terkelsen 2010]. Combination therapy, initial thrombolysis with subsequent PCI, is another method of improving outcomes when long transports for PCI are inevitable [Boden et al. 2007; Millin et al. 2008]. In this case, given the D/O's deteriorating clinical status, the decision to transport directly to the local ED seemed appropriate.

Finally, prehospital thrombolysis was available but was not approved to be administered until the D/O was in the ED. If approved enroute, it would have initiated thrombolytic therapy about 10-15 minutes sooner. Whether this time savings would have changed the clinical outcome is unclear. A fire service document is available to help the fire service and EMS community optimize treatment for STEMI patients [IAFF 2007].

***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 medical requirements for candidates and current fire fighters. NFPA 1582 recommends that all firefighters receive annual medical evaluations. NFPA also recommends "Stress EKG with or without echocardiogram or radionuclide scanning shall be performed as clinically indicated by history or symptoms" and refers the reader to Appendix A for explanatory material. Material in Appendix A is for "informational purposes only," and considered standard recommendations, not standard requirements. Appendix A, section A.7.7.6.3 recommends sub-maximal (85% of predicted heart rate) stress tests be used as a screening tool to evaluate a fire fighter's aerobic capacity. Maximal (e.g., symptom limiting) stress tests with imaging should be used for fire fighters with:

- abnormal screening sub-maximal tests
- cardiac symptoms
- coronary artery disease
- Males over the age of 45 and females over the age of 55 with two or more risk factors for coronary artery disease. Risk factors are defined as hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (diastolic blood pressure greater than 90 mm Hg), smoking, diabetes mellitus, or family history of premature coronary artery disease (heart attack or sudden cardiac death in a first-degree relative less than 60 years old).

This recommendation is similar to that of the American Heart Association and American College of Cardiology (AHA/ACC) and the Department of Transportation (DOT) regarding exercise stress tests in asymptomatic persons [Gibbons et al. 2002; Blumenthal et al. 2007].

The D/O was 58 and had several CAD risk factors (smoking, hypercholesterolemia, family history) which, according to NFPA 1582, indicated the

## Discussion (cont.)

need for an exercise stress test to be medically cleared for structural firefighting and emergency response duty. Had an exercise stress test been performed, perhaps the D/O's underlying CAD would have been identified leading to further evaluation, treatment, and possible reduction in his risk for a STEMI and cardiac death.

## Recommendations

The NIOSH investigators offer the following recommendations to address general safety and health issues. Had these recommended measures been in place prior to D/O's illness, his cardiac death may have been prevented.

***Recommendation #1: Provide mandatory preplacement and annual medical evaluations to fire fighters consistent with National Fire Protection Association (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-FitnessTask Force: Wellness-Fitness Initiative (WFI) [NFPA 2007a; IAFF, IAFC 2008a]. 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. However, the FD is not legally required to follow these standards. Applying this recommendation involves economic repercussions and may be particularly difficult for small volunteer FDs to initiate. Despite substantial financial obstacles to implementation of these recommendations, volunteer FDs will find existing guidelines available and worthwhile [USFA 2009].

***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.***

Guidance regarding medical evaluations and examinations for structural fire fighters can be found in NFPA 1582 [NFPA 2007a] and in the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Task Force: Wellness-Fitness Initiative (WFI) [IAFF, IAFC 2008a]. 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 must perform, as well as the personal protective equipment they must wear during various types of emergency operations. This recommendation is based on review of the FD health and medical programs. Access to medical care is a nation-wide problem, and lack of insurance directly impacted this D/O's ability to receive clearance for duty. Regardless, at his last physical exam in 2003, the D/O's primary care physician knew of his CAD risk factors. There is no mention of his fire fighting duties, so it is unclear whether the D/O's physician was aware that his patient was a fire fighter. Neither his medical nor his FD records mentioned medical clearance for duty.

## Recommendations (cont.)

***Recommendation #3: Develop a job-related, comprehensive wellness/fitness program for fire fighters.***

Guidance for FD 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 Task Force: Wellness-Fitness Initiative (WFI), and the National Volunteer Fire Council (NVFC) Health and Wellness Guide, and in Firefighter Fitness: A Health and Wellness Guide [USFA 2009; IAFF, IAFC 2008a; 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 coronary artery 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 2007].

Given the FD's structure, the NVFC program might be a useful model [USFA 2009]. NIOSH recommends a formal, structured wellness/fitness program to ensure all members receive the benefits of a health promotion program.

***Recommendation #4: Educate fire fighters on the signs and symptoms of a heart attack.***

Recognizing the signs and symptoms of a heart attack is difficult, particularly in oneself. This is especially true if the symptoms can be attributed to physical exertion such as shortness of breath due to sprinting 100 yards, or the adrenaline rush from slamming on the brake to avoid hitting a deer. However, the D/O's shortness of breath resolved as his chest pain (angina) began and yet he continued to drive the engine/tanker. Fire fighters experiencing symptoms or signs suggestive of angina should be removed from dangerous environments, including driving, as medical authorities are notified. If the D/O lost consciousness while driving, this would have jeopardized not only the life of the D/O and the fire fighter in the passenger seat, but other civilians on-or-off the road [NIOSH 2002]. In 2009, the USFA published a health and wellness guide for the volunteer fire service that includes education of the signs and symptoms of heart disease and risk factors for CAD [USFA 2009].

***Recommendation #5: Perform a pre-placement and an annual physical performance (physical ability) evaluation.***

The IAFF/IAFC has developed a validated test for candidates known as the CPAT (Candidate Physical Ability Test) [IAFF/IAFC 2008b] to evaluate whether individuals are physically capable of performing essential tasks of firefighting. NFPA 1583 outlines basic guidelines for ongoing, job-related fitness programs for fire departments. While the pro-

## Recommendations (cont.)

visions of NFPA 1583 do not aim to disqualify FD members on the basis of their strength and fitness, they do ensure that members are evaluated annually so that declining fitness levels can be addressed before they lead to occupational illness or injury.

***Recommendation #6: Provide fire fighters with medical clearance to wear self-contained breathing apparatus as part of a Fire Department medical evaluation program.***

The Occupational Safety and Health Administration (OSHA) Revised Respiratory 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. North Carolina operates an OSHA-approved State plan; therefore, public sector employers (including volunteer/paid fire departments) are required to comply with OSHA standards.

## References

AHA [2005]. 2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Part 8: Stabilization of the Patient with Acute Coronary Syndromes. Circulation *112*(Suppl IV):IV-89-IV-110.

AHA [2012]. Understanding your risk of a 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: September 2012.

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.

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: August 2011.

Boden WE, Eagle K, Granger CB [2007]. Reperfusion strategies in acute ST-segment elevation myocardial infarction: a comprehensive review of contemporary management options. J Am Coll Cardiol. *50*(10):917-29.

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

Dahabreh IJ, Paulus JK [2011]. Association of episodic physical and sexual activity with triggering of acute cardiac events. Systematic review and meta-analysis. JAMA 305:1225-1233.

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.

## References (cont.)

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.

IAFF [2007]. Prehospital 911 Emergency Medical Response: The Role of the United States Fire Service in Delivery and Coordination. [http://www.iaff.org/tech/PDF/FB%20EMS%20Whitepaper%20FINAL%20July%205%202007%20.pdf] Accessed August 2011.

IAFF, IAFC [2008a]. The fire service joint labor management wellness/fitness task force: Wellness-fitness initiative (WFI). 3rd ed. Washington, DC: International Association of Fire Fighters, International Association of Fire Chiefs.

IAFF, IAFC [2008b]. The fire service joint labor management wellness-fitness task force: Candidate physical ability test (CPAT) program. 2nd 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: August 2010.

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 K [2007]. Economic impact of the wellness fitness initiative. Presentation at the 2007 John P. Redmond Symposium in Chicago, IL on October 23, 2007.

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.

Millin MG, Brooks SC, Travers A [2008]. Emergency medical services management of ST-elevation myocardial infarction. Prehosp Emerg Care *12*(3):395-403.

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 [2007a]. Standard on comprehensive occupational medical program for fire departments. Quincy, MA: National Fire Protection Association. NFPA 1582.

## References (cont.)

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 [2011]. Who is at risk for coronary artery disease? National Heart, Lung, and Blood Institute. [http://www.nhlbi.nih.gov/health/dci/Diseases/Cad/CAD_WhoIsAtRisk.html]. Date accessed: August 2011.

NIOSH [2007]. NIOSH alert: preventing fire fighter fatalities due to heart attacks and other sudden cardiovascular events. 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. [http://www.cdc.gov/niosh/docs/2007-133/] Date accessed: August 2011

NIOSH [2002]. Fire Fighter Fatality Investigation Report F2002-05. Fire Fighter Suffers Sudden Cardiac Death and Crashes Tanker While Responding to a Chimney Fire – Colorado. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. [http://www.cdc.gov/niosh/fire/reports/face200205]. Date accessed: August 2011.

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

Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. Clin Cardiol *20*(11 Suppl2):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.

Terkelsen CJ, Christiansen EH, Sørensen JT, Kristensen SD, Lassen JF, Thuesen L, Andersen HR, Vach W, Neilsen TT [2009]. Primary PCI as the preferred reperfusion therapy in STEMI: it is a matter of time. Heart 95:362-369.

Terkelsen CJ, Sørensen JT, Maeng M, Jensen LO, Tilsted HH, Trautner S, Vach W, Johnsen SP, Thuesen L, Lassen, JF [2010]. System delay and mortality among patients with STEMI treated with primary percutaneous coronary intervention. JAMA 304:763-771.

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.

# *Driver/Operator Suffers Fatal Heart Attack While Responding to Structure Fire – North Carolina*

## Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio. Carin VanGelder, MD and Sandy Bogucki, MD, PhD led the investigation and coauthored the report. Dr. VanGelder is an Assistant Professor and Dr. Sandy Bogucki is an Associate Professor in the Department of Emergency Medicine at the Yale University School of Medicine; they were assisted by John Ahern, a student intern at Yale. Dr. Bogucki is the task group Chair for NFPA 1582. Both Dr. VanGelder and Dr. Bogucki were working as contractors with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component during this investigation. Thomas Hales, MD, MPH, reviewed the report for NIOSH. Dr. Hales is the team leader for the Cardiovascular Disease Component, 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).