



Fire Chief Suffers Fatal Heart Attack – New Hampshire

Executive Summary

On September 2, 2012, a 52-year-old Fire Chief experienced chest pains while working at the station. Fire department (FD) personnel transported the Chief to the hospital where he suffered a cardiac arrest and died. The death certificate and autopsy report listed the cause of death as “acute myocardial infarction” due to “arteriosclerotic cardiovascular disease.” Activities at the fire station on the morning of September 2 and his duties as the Fire Chief during the State Fair were temporally related to his angina, heart attack, and sudden 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.

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

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

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

Introduction & Methods

On September 2, 2012, a 52 year-old Fire Chief experienced angina while working at one of the FD’s stations. He was transported to the emergency department (ED), where he suffered cardiac arrest and died. NIOSH was notified of this fatality on September 4, 2012, by the U.S. Fire Administration. NIOSH contacted the affected FD on September 25, 2012, and again on April 8, 2013, to obtain additional information and to schedule the investigation. On April 17, 2013, a contractor for the NIOSH Fire Fighter Fatality Investigation Team (the NIOSH investigator) conducted an on-site investigation of the incident.

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

- Current Chief of the FD
- Crew members who were working with the deceased Chief and provided initial emergency medical service (EMS) treatment
- Wife of the deceased Chief

The NIOSH investigator reviewed the following documents in preparing this report:

- FD general operating procedures
- Ambulance pre-hospital care report
- Death certificate
- Medical examiner’s report
- Primary care physician (PCP) medical records
- Hospital records

Fire Chief Suffers Fatal Heart Attack – New Hampshire

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 or call toll free 1-800-CDC-INFO (1-800-232-4636).

Fire Chief Suffers Fatal Heart Attack – New Hampshire

Investigative Results

Incident. On September 2, 2012, at 1200 hours the Chief began an 8-hour shift at the fire station. The FD's town hosts the annual State Fair. During the Fair, the calls to the FD increase dramatically. To accommodate the increased activity, the FD temporarily assigns a 2nd "chief officer at the fair grounds" and another "Chief Officer at the station." On September 2, the fourth day of the State Fair, the Chief was scheduled to be the Chief Officer at the station for an 8-hour shift (1200 hours to 2000 hours). The preceding day (September 1) the Chief served as the Chief Officer at the fair grounds for 16 hours (0800 hours to 2400 hours). The morning of September 2, several members of the FD noted that the Chief seemed "stressed" due to the added work and responsibility of the Fair.

At approximately 1545 hours the Chief approached two FD EMS personnel (a paramedic and an Emergency Medical Technician-Intermediate) and requested a medical evaluation. The Chief was in no apparent distress but reported intermittent chest pain since the beginning of his shift (1200 hours). The pain was described as sudden onset, non-radiating, substernal chest pain lasting about 30 seconds whose severity was a "7" on a 1–10 scale. The Chief was not short of breath or nauseated, but he was sweaty.

The Chief's blood pressure was normal [126/74 millimeters of mercury (mmHg)], his pulse was normal (64 beats per minute), and his respiratory rate was normal (14 breaths per minute). The 12 lead electrocardiogram (EKG) showed a normal sinus rhythm, but a borderline (1 mm) ST elevation in V2 suggested possible cardiac injury. The paramedic recommended transport to the hospital's ED, but the Chief remarked that the pain was gone and he declined transport. The Chief stated

he planned to go home early, but within 2 minutes, the Chief's chest pain returned and he requested transport to the hospital ED.

At 1554 hours, the paramedic notified dispatch of a "medical walk-in" (the Chief) at the fire station. The Chief was placed in the patient compartment of the ambulance which departed the station at 1555 hours. Aspirin and three doses of sublingual nitroglycerin were given en route, relieving the Chief's chest pain. The paramedic also administered Fentanyl® for pain and Versed® for anxiety. During transport the Chief's vital signs rose: blood pressure 184/96 mmHg, pulse 84 beats per minute, and respiratory rate 20 breaths per minute.

The ambulance arrived at the ED at 1609 hours and care was transferred to ED personnel. The Chief was alert and interactive as he entered the ED. An EKG obtained in the ED showed changes consistent with a heart attack (acute anteroseptal myocardial infarction). The ED physician activated the cardiac catheterization lab team while he obtained the Chief's medical history. The ED physician provided nitroglycerin sprays which seemed to alleviate the pain. As the ED physician was obtaining the medical history and as the cardiologist arrived at the Chief's bedside, the Chief went into cardiac arrest with a heart rhythm of ventricular fibrillation. Chest compressions were started immediately and a shock was delivered, but his ventricular fibrillation persisted. Advanced cardiac life support protocols were followed which included additional shocks, cardiac medications, intubation, and chest compressions using a LUCAS® device. The Chief was taken emergently to the cardiac catheterization lab at 1719 hours to restore blood flow to the heart muscle. Despite all efforts, the Chief never regained a viable heart rhythm or pulse, and at 1849 hours he was pronounced dead.

Fire Chief Suffers Fatal Heart Attack – New Hampshire

Investigative Results (cont.)

Medical Findings. The death certificate and autopsy, both completed by the Chief Medical Examiner, listed the cause of death as “acute myocardial infarction” due to “arteriosclerotic heart disease.” Pertinent autopsy findings included the subtotal occlusion of the proximal left anterior descending coronary artery with plaque hemorrhage, arteriosclerotic occlusion of the diagonal branches, and cardiomegaly (440 grams; expected weight 352 grams) with biventricular dilation. See Appendix A for complete autopsy information.

The Chief was diagnosed with hypertension in 2009. His blood pressure was well controlled with a beta-blocker medication as evidenced by his last blood pressure of 122/70 mmHg in August 2011. The Chief had received counseling from his physician about high triglyceride levels and had been following good dietary habits and exercising regularly. Laboratory tests completed within 1 week of the August 2011 physical examination indicated total cholesterol of 174 milligrams per deciliter (mg/dL) (desirable < 200 mg/dL) [National Cholesterol Education Program 2002], high density lipoprotein (HDL cholesterol) of 40 mg/dL (normal 40-59 mg/dL), and low density lipoprotein (LDL cholesterol) of 109 mg/dL (optimal < 100 mg/dL; near optimal 100-129 mg/dL; borderline high 130-159 mg/dL) [National Cholesterol Education Program 2002].

The Chief went to the ED with complaints of chest pain in January 2009. At that time, the EKG revealed a normal sinus rhythm with no ischemic changes. His laboratory evaluations, including cardiac enzymes, were all within normal limits. The Chief followed up with his PCP 2 weeks later at which time he indicated that the pain was associated with movement and not cardiac related.

The Chief was 73 inches tall and weighed about 214 pounds, giving him a body mass index of 28.2 kilograms per meter squared [CDC 2013]. He was a non-smoker, was conscientious about eating a diet high in fruits and vegetables, and engaged in aerobic exercise at least 5 days per week.

Description of the Fire Department

The Chief served as a paid chief of a department that consisted of 39 uniformed personnel (including career and volunteer staff) serving a population of 5,600 residents. The FD has two fire stations and serves a geographic area of 43 square miles. The FD is also contracted to provide EMS coverage to approximately 10,000 residents in surrounding towns. During the week of the State Fair, the population of the area swells by approximately 25,000 people per day.

Employment and Training. Candidates for paid positions at the FD must take a written test, pass a physical agility test, pass a background check and be certified as a Firefighter II (based on New Hampshire State guidelines), a Hazmat Operator, and an Emergency Medical Technician-Intermediate. Candidates for volunteer positions at the FD must possess a valid driver’s license, successfully pass a background check, present a note from their physician saying they can medically do the job, and be voted onto the FD by member of the FD Association. Volunteer fire fighters must be certified as a Firefighter I by the end of their probationary year.

Pre-placement and Period Medical Evaluations. The FD does not require pre-placement or periodic medical evaluations. However, volunteers who join the department must present a note from their

Fire Chief Suffers Fatal Heart Attack – New Hampshire

Description of the FD (cont.)

personal physician that states they are medically cleared to be a firefighter.

Medical Clearance. A fire fighter injured at work must be evaluated and cleared for “return to work” by their PCP.

Fitness/Wellness Programs. The FD does not provide exercise equipment or an exercise program. However, FD personnel can use the police department’s fitness facilities when they are off-duty free of charge.

Discussion

Coronary Heart Disease (CHD) and the Pathophysiology of Sudden Cardiac Death. The Chief experienced chest pains (angina) while working at the station. The most common risk factor for cardiac arrest and sudden cardiac death is CHD, defined as the build-up of atherosclerotic plaque in the coronary arteries [AHA 2012]. Risk factors for CHD 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 Chief had four of these risk factors (male, over the age of 45, family history of CHD, and hypertension). It is important to note that the Chief’s hypertension was under good control and that he embraced life-style changes (diet and regular exercise) to successfully treat his high blood lipids.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2005]. However, the growth of these plaques probably occurs in a nonlinear, often

abrupt fashion [Shah 1997]. Most heart attacks occur when a vulnerable plaque ruptures, causing a blood clot to form and occlude a coronary artery. Establishing a recent (acute) heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes, or coronary artery thrombus. In this case, the Medical Examiner found plaque hemorrhage with near occlusion of the proximal portion of the left anterior descending coronary artery indicating an acute myocardial infarction due to plaque rupture and thrombus formation. Activities at the fire station on the morning of September 2 and his duties as the fire Chief during the State Fair were temporally related to his angina, heart attack, and sudden cardiac death.

Occupational Medical Standards for Structural Firefighting. 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 2007, 2013]. This voluntary industry standard provides (1) the components of a preplacement and annual medical evaluation and (2) medical fitness for duty criteria. The FD does not currently require medical evaluations of personnel, however, the Chief saw his PCP yearly for physical evaluations and was successful in treating his modifiable CHD risk factors.

On autopsy, the Chief was found to have CHD. Exercise stress tests can be used to identify occult CHD. However, recommendations for conducting exercise stress tests on asymptomatic individuals without known heart disease are varied. The following paragraphs summarize the positions of widely recognized organizations on this topic.

Fire Chief Suffers Fatal Heart Attack – New Hampshire

Discussion (cont.)

NFPA 1582, a voluntary industry standard, recommends an exercise stress test performed “as clinically indicated by history or symptoms” and refers the reader to its Appendix A [NFPA 2007]. Items in Appendix A are not standard requirements, but are provided for “informational purposes only.” Appendix A recommends using submaximal (85% of predicted heart rate) stress tests as a screening tool to evaluate a fire fighter’s aerobic capacity. Maximal (i.e., symptom-limiting) stress tests with imaging should be used for fire fighters with the following conditions:

- abnormal screening submaximal tests
- cardiac symptoms
- known coronary artery disease (CAD)
- two or more risk factors for CAD (in men older than 45 and women older than 55)

Risk factors are defined as hypercholesterolemia (total cholesterol greater than 240 milligrams per deciliter), hypertension (diastolic blood pressure greater than 90 mm of mercury), smoking, diabetes mellitus, or family history of premature CAD (heart attack or sudden cardiac death in a first-degree relative less than 60 years old).

The American College of Cardiology/American Heart Association (ACC/AHA) has also published exercise testing guidelines [Gibbons et al. 2002]. The ACC/AHA guideline states the evidence is “less well established” (Class IIb) for the following groups:

- persons with multiple risk factors (defined similarly to those listed by the NFPA)
- asymptomatic men older than 45 years and women older than 55 years:
 - who are sedentary and plan to start vigorous exercise
 - who are involved in occupations in which impairment might jeopardize public safety (e.g., fire fighters)

- who are at high risk for CAD due to other diseases (e.g., peripheral vascular disease and chronic renal failure)

The U.S. Department of Transportation provides guidance for those seeking medical certification for a commercial driver’s license. An expert medical panel recommended exercise tolerance tests (stress tests) for asymptomatic “high risk” drivers [Blumenthal et al. 2007]. The panel defines high risk drivers as those with any of the following:

- diabetes mellitus
- peripheral vascular disease
- age 45 and above with multiple risk factors for coronary heart disease
- Framingham risk score predicting a 20% coronary heart disease event risk over the next 10 years

The U.S. Preventive Services Task Force (USPSTF) does not recommend stress tests for asymptomatic individuals at low risk for coronary heart disease events. For individuals at increased risk for coronary heart disease events, the USPSTF found “insufficient evidence to recommend for or against routine screening with EKG, exercise tolerance test, or electron beam computerized tomography scanning....” Rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes) [USPSTF 2004]. The USPSTF does note that “For people in certain occupations, such as pilots, and heavy equipment operators (for whom sudden incapacitation or sudden death may endanger the safety of others), consideration other than the health benefit to the individual patient may influence the decision to screen for coronary heart disease.”

Fire Chief Suffers Fatal Heart Attack – New Hampshire

Discussion (cont.)

In summary, the guidelines of these organizations provide conflicting advice as to whether the Chief should have had a stress test. NFPA guidelines suggest a stress test was indicated based on his family history of CHD and hypertension (even if well treated). The AHA and the USDOT guidelines also seem to recommend a stress test based on his having multiple CHD risk factors (assuming “multiple” is defined as ≥ 2 CHD risk factors). The USPSTF guidelines would not have recommended a stress test. Had a stress test been performed, perhaps his underlying CHD could have been identified and subsequently treated.

NIOSH offers these recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters.

Recommendations

NIOSH investigators offer the following recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters.

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

Guidance regarding the content and frequency of these medical evaluations can be found in NFPA 1582 and in the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) Fire Service Joint Labor Management Wellness/Fitness Initiative [NFPA 2007; 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. 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 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.

Fire Chief Suffers Fatal Heart Attack – New Hampshire

Recommendations (cont.)

According to NFPA 1582 and the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, the FD should have an officially designated physician who is responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty [NFPA 2007; NFPA 2013; IAFF/IAFC 2008]. The physician should review job descriptions and essential job tasks required for all FD positions to understand the physiological and psychological demands of firefighting and the environmental conditions under which fire fighters perform, as well as the personal protective equipment they must wear during various types of emergency operations. In addition, this physician should oversee all fitness for duty recommendations provided by PCPs and have the final authority for all medical fitness for duty decisions. To ensure the FD physician or other PCP is familiar with NFPA 1582, the NIOSH investigators recommend the FD provide a copy or a link to the NFPA website where a copy could be purchased or viewed on-line at no charge.

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 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 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.

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Fire Chief Suffers Fatal Heart Attack – New Hampshire

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Fire Chief Suffers Fatal Heart Attack – New Hampshire

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Investigator Information

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

Fire Chief Suffers Fatal Heart Attack – New Hampshire

Appendix A

Autopsy Findings

- Heart Size & Structure
 - Heart weight = 440 grams (expected weight 352 grams) [Silver and Silver 2001]
 - Biventricular dilation
 - Left ventricular hypertrophy
 - Left ventricular wall = 1.4 cm
 - Right ventricular wall = 0.5 cm
- Coronary Arteries
 - Status-post stent placement in left anterior descending coronary artery
 - Arteriosclerotic occlusion of diagonal branches
- Microscopic examination
 - Diffuse myocyte hypertrophy with minimal perivascular and interstitial fibrosis in left ventricle.
 - Evidence of chronic ischemia (vacuolization of subendocardial myocytes)
 - Global recent ischemia (hypereosinophilia and waviness of myofibers with smudging of cross-striations and focal contraction band necrosis)
- No drugs of abuse detected

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