



Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

January, 2008

Fire Chief Suffers Sudden Cardiac Death After Strenuous Training Drill - New York

SUMMARY

On April 4, 2006, a 57-year-old male volunteer Fire Chief participated in a smoke drill. The Chief assisted with setting up the training site by loading, unloading, and setting up empty 55-gallon drums, bales of hay, and hose lines. After the drill, the Chief assisted with cleanup activities that included rolling and loading the hose lines. At about 2300 hours, the Chief went home. At some point after taking out his trash and taking a shower, the Chief suffered an unwitnessed collapse. A family member found him early the next morning (April 5th), obviously deceased. Although 9-1-1 was called and an ambulance responded, resuscitation measures were not performed due to the Chief's prolonged deceased status. The Coroner was notified, responded to the scene, and pronounced the Chief dead at 0557 hours. The death certificate (completed by the Coroner) listed "presumed sudden cardiac death" due to "coronary artery disease" as the cause of death. No autopsy was performed. Approximately 9 weeks later, a letter to the funeral director by the Chief's personal physician, stated "death was from plaque rupture in the coronary circulation leading to coronary thrombosis, myocardial infarction, and fatal arrhythmia." The NIOSH investigator concluded that the physical stress of moving the barrels and hay, and stretching, rolling, and loading hose lines, coupled with the Chief's underlying coronary artery disease (CAD), probably triggered his sudden cardiac death.

The NIOSH investigator offers the following recommendations to prevent similar incidents and to address general safety and health issues.

- *Ensure all fire department members participate in Fire Department pre-placement and periodic medical evaluations.*
- *Ensure fire fighters at risk for CAD receive exercise stress tests.*
- *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.*
- *Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural firefighting.*

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636)



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- *Develop a structured wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.*
- *Perform an autopsy on all on-duty fire fighter fatalities.*

INTRODUCTION & METHODS

On April 4, 2006, a 57-year-old male volunteer Fire Chief died after strenuous activities associated with a smoke drill. NIOSH was notified of this fatality on April 7, 2006 by the United States Fire Administration. NIOSH contacted the affected Fire Department on April 10, 2006 to obtain further information, and on November 8, 2007 to initiate the investigation. On November 26, 2007, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to New York to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Current Fire Chief
- Deputy Fire Chief
- Deceased Fire Chief's spouse

NIOSH personnel reviewed the following documents:

- Fire Department incident reports
- Witness statements
- Fire Department annual 2006 response report
- Death certificate
- Primary care physician records
- Commercial Driver's License medical evaluation reports

RESULTS OF INVESTIGATION

Incident. On April 4, 2006, the Chief arrived at his regular job at 0800 hours. At 0900 hours, he drove a bus to another city for repairs--the trip taking about 1 hour each way. He returned to his office at 1300 hours. At 1500 hours, the Chief left his office and went to the Fire Department to begin preparations for the smoke drill scheduled that evening. He and a crew member went to the training site, a single-family, wood-frame residence, and set up the training props. They unloaded four empty 55-gallon drums and five bales of hay from the trailer and carried the items into the house. They placed the hay into the barrels; the hay would be burned to produce smoke for the search and rescue training. At 1730 hours, the Chief left for home to eat dinner with his spouse.

After dinner, the Chief returned to the Fire Department (1800 hours). Crew members left the fire station and arrived at the training site at 1830 hours. The Chief assisted in setting up 5-inch and 2½-inch supply hose lines and 1½-inch attack hose lines, and moving and placing hay bales as needed. After the training started, the Chief placed the Assistant Chief in charge of the training, and returned to the fire station to retrieve equipment (batteries and lights).

After the training was completed (2130 hours), the Chief returned to the training site and assisted in rolling and loading the hose and equipment onto the trailer for transport back to the Fire Department. Each 100-foot section of 5-inch supply hose weighed about 97 pounds, each 50-foot section of 2½-inch supply hose weighed about 30 pounds, and each 50-foot section of 1½-inch attack hose weighed about 18 pounds. The Chief returned to the Fire Department to



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complete training paperwork at 2230 hours, and left for home at 2300 hours.

Once at home, the Chief took out the trash, turned the television on, and took a shower. A family member came downstairs at about 0200 hours and noticed that the bathroom light and fan were on and the door was closed. After going back to bed, the family member came downstairs again at about 0545 hours and noticed that the bathroom door was still closed and the bathroom light and fan were still on. The family member knocked on the door and got no response, then went outside and peered into the bathroom window and saw the Chief collapsed on the floor. The family member called 9-1-1 and an ambulance was dispatched.

The ambulance arrived at the scene, and ambulance personnel found the Chief to be deceased. The Coroner was notified, responded to the scene, and pronounced the Chief dead at 0557 hours.

Medical Findings. The death certificate (completed by the Coroner) listed "presumed sudden cardiac death" due to "coronary artery disease" as the cause of death. No autopsy was performed. Approximately 9 weeks later, a letter to the funeral director by the Chief's personal physician, stated that the Chief's "death was from plaque rupture in the coronary circulation leading to coronary thrombosis, myocardial infarction, and fatal arrhythmia."

The Chief was 73 inches tall and weighed 248 pounds, giving him a body mass index (BMI) of 32.7. A BMI >30.0 (kilograms per meters squared [kg/m^2]) is considered obese [National Heart, Lung and Blood Institute 2005]. The Chief had a history of hypertension since 1998 and

was prescribed an antihypertensive medication, which controlled his blood pressure. He also had a history of high triglycerides since 2001 and was prescribed a lipid-lowering medication, which controlled his blood triglyceride level. He had been prescribed weight reduction, diet, and exercise since 2001, and had lost 40-50 pounds during a 4-month period in 2005 by dieting and exercising. In 1999, the Chief was diagnosed with prostate cancer and was treated with surgery.

In 2001 the Chief had exercise stress tests to screen for coronary artery disease. The test used persantine (a persantine cardiolite study), rather than exercise, to increase the participant's heart rate. The Chief reached a peak blood pressure of 166/98 millimeters of Mercury (mmHg) and a maximum heart rate of 73 (43% of his maximum predicted heart rate) (probably due to taking anti-hypertensive medication). The test was terminated due to completed protocol. The Chief did not experience any chest discomfort and the EKG showed nonspecific ST-T wave changes.

The Chief had another exercise stress test in 2005. The Chief exercised, using the Bruce Protocol, for 11 minutes, 1 second (13.5 metabolic equivalents [METS]) reaching a peak heart rate of 157 beats per minute (95% of his maximum). His blood pressure rose during the treadmill test to 180/110 mmHg. The test EKG revealed horizontal ST segment depressions (2.0-2.1 mm) in the inferior lateral leads, suggestive of ischemia. The test was considered positive for exercise-induced ischemia based on EKG criteria pending the imaging portion of the test. The imaging portion of the test was a gated myocardial single photon emission computed tomography (SPECT) scan which revealed no



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significant fixed or reversible perfusion defects, a normal left ventricular wall motion, and a normal ejection fraction of 56%. These findings required the cardiologist to reconcile conflicting results from the exercise stress test: a positive test by EKG versus a negative test by lack of symptoms, adequate blood pressure response, no heart arrhythmias, and normal imaging results. The cardiologist concluded that the exercise stress test was negative.

The Chief passed a medical evaluation for a commercial driver's license 7 days before his death. According to his family and crew members, the Chief had no complaints of chest pains, unusual shortness of breath on exertion, or any other heart-related illness.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this volunteer Fire Department consisted of 43 uniformed personnel, and served a population of 7,000 in a 3.9-square-mile area. It had one fire station. In 2006, the Fire Department responded to 466 calls (300 rescue/medical calls, 28 fire calls, 24 hazardous condition calls, 18 service calls, 14 good intent calls, 74 false alarms, 4 overpressure, explosion, or overheat calls, and 4 weather calls).

Membership and Training. The Fire Department requires the following of all fire fighter applicants:

- Be at least 18 years of age
- Complete an application

- Pass an interview by a committee
- Pass a fire company vote
- Be approved by the Village board
- Pass a pre-placement medical evaluation

The successful applicant is placed into a training program and is trained to the State Fire Fighter I and II levels for interior fire fighters. The fire fighter is placed on probation for 1 year and must complete the required training during this time. The fire fighter must also attend 50% of the Fire Department training sessions. There are no State minimum standards for volunteer fire fighters. New York is an Occupational Safety and Health Administration (OSHA) State-plan State [OSHA 2006], and paid and volunteer fire departments are required to comply with OSHA standards. The Chief was certified as an FFII, Emergency Medical Technician, Driver/Operator, Instructor, Fire Inspector, Dispatcher, and in Hazardous Materials Awareness. He had 39 years of firefighting experience.

Pre-placement Medical Evaluation. A pre-placement medical evaluation is required for all new members, regardless of age. Components of this evaluation include:

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Urine dipstick test
- Urinalysis
- Vision testing
- Hearing screen

This evaluation is performed by the Fire Department-contracted physician, who makes a decision regarding medical clearance for firefighting duties. Follow-up by the member's



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primary care physician may be required prior to final clearance for duty.

Annual Medical Evaluations. Annual medical evaluations are required for all fire fighters. Components of this evaluation are the same as those of the pre-placement medical evaluation. Medical clearance for self-contained breathing apparatus (SCBA) use is required for all fire fighters.

If a fire fighter is injured on duty, a return-to-duty medical clearance is required from the fire fighter's primary care physician. The clearance is given to the Fire Chief, who makes the final determination for return-to-duty. The clearance is filed with the Village clerk's office. If an off-duty injury or illness prevents a fire fighter from performing his or her duty, no return-to-duty clearance is required.

Health/Wellness Programs. The Fire Department does not have a physical fitness program, however strength and aerobic equipment is available in the fire station. An annual physical ability test is not required.

DISCUSSION

Coronary Artery Disease and the Pathophysiology of Heart Attacks. In the United States, atherosclerotic CAD is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2005]. Risk factors for its development include age over 45, male gender, family history of CAD, high blood pressure, high blood cholesterol, obesity,

physical inactivity, and diabetes [American Heart Association (AHA) 1998; Jackson et al. 2001]. The Chief had four of these risk factors (age over 45, male gender, hypertension, and obesity).

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]. 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.

Diagnosing a heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes, or coronary artery thrombus [AHA 2006]. The Chief was found several hours after he died; an EKG was not performed, cardiac enzymes were not tested, and no autopsy was conducted. Therefore, NIOSH investigators cannot confirm he had a heart attack, but the clinical scenario is consistent with a heart attack. The fact that the Chief was asymptomatic does not rule out a heart attack because not all heart attacks have symptoms of chest pain and/or shortness of breath. Since the Chief had performed exertional activities at the smoke drill and did not complain of these symptoms, it is possible he suffered a "silent" or asymptomatic heart attack. In up to 20% of individuals, the first evidence of CAD may be myocardial infarction or sudden death [Libby 2005; Thaulow et al. 1993].



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Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks [Willich et al. 1993; Mittleman et al. 1993; Siscovick et al. 1984; Tofler et al. 1992]. 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 Chief had set up the training props and hoselines prior to the training, and rolled hoselines and loaded equipment after the training. This activity expended about 10 METs, which is considered heavy physical activity [American Industrial Hygiene Association Journal 1971; Ainsworth 2003; Ainsworth et al. 1993; Gledhill and Jamnik 1992]. Given the Chief's probable underlying CAD, the physical stress of performing exertional training activities could have triggered a heart attack, causing his subsequent cardiac arrest and death.

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac death or other incapacitating medical conditions among fire fighters, the NFPA developed NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments* [NFPA 2007a]. NFPA recommends annual medical evaluations and include an exercise stress test for fire fighters at increased risk for CAD (such as this Fire Chief). While the Fire Department and the State required an annual medical evaluation, there was no record of these evaluations for the Chief. Nonetheless, the Chief did have an exercise stress test performed by his personal physicians 10 months prior to his death. As noted previously, the findings of this test were mixed; some components suggested he had exercise-induced ischemia (EKG), while other

components (e.g., imaging test) suggested he did not have ischemia. In retrospect, his exercise stress test may have been a false negative test, which can happen in about 5% of imaging exercise stress tests [Grundy 2003].

RECOMMENDATIONS

The NIOSH investigator offers the following recommendations to prevent similar incidents and to address general safety and health issues.

Recommendation #1: Ensure all fire department members participate in Fire Department pre-placement and periodic medical evaluations.

The State requires pre-placement and annual medical evaluations. However, these evaluations are not completely NFPA-compliant. Guidance regarding the content and frequency of these evaluations can be found in NFPA 1582 [NFPA 2007a] and in the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) *Fire Service Joint Labor Management Wellness/Fitness Initiative* [IAFF, IAFC 2000]. The Fire Department is not legally required to follow this standard or this initiative.

Recommendation #2: Ensure fire fighters at risk for CAD receive exercise stress tests.

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 2000]. Both guidelines, as well as the ACC/AHA guidelines recommend an exercise stress test for male fire fighters over the age of 45 with



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two or more CAD risk factors [NFPA 2007a; Gibbons et al. 2002; IAFF, IAFC 2000]. The exercise stress tests could be conducted by the fire fighter's personal physician or the City contract physician. If the fire fighter's personal physician conducts the test, the results must be communicated to the City physician, who should be responsible for decisions regarding medical clearance for firefighting duties.

Recommendation #3: 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 Initiative* [IAFF, IAFC 2000]. According to these guidelines, the Fire Department should have an officially designated physician who is responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty as required by NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program* [NFPA 2007b]. The physician should review job descriptions and essential job tasks required for all Fire Department positions and ranks, in order 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.

Recommendation #4: Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural firefighting.

NFPA 1500 recommends Fire Department members who engage in emergency operations to be annually evaluated and certified by the Fire Department as having met the physical performance requirements identified in paragraph 8-2.1 of the standard [NFPA 2007b].

Recommendation #5: Develop a structured wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Additionally, physical inactivity (or lack of exercise) is associated with other risk factors, namely obesity and diabetes [Plowman and Smith 1997]. NFPA 1500 recommends that a Fire Department have a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being [NFPA 2007b]. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days [Maniscalco et al. 1999; Stein et al. 2000; Aldana 2001]. Health promotion programs in the fire service have been shown to reduce CAD risk factors and improve fitness levels, with mandatory programs showing the most benefit [Blevins et al. 2006; Dempsey et al. 2002; Womack et al. 2005]. One mandatory program was able to show a cost savings of \$68,741 due to reduced absenteeism [Stevens et al. 2002]. A similar cost savings has been reported by the wellness



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program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs [City Auditor, City of Phoenix, AZ 1997]. Guidance for implementation and components of a comprehensive wellness/fitness program are found in NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters* [NFPA 2000], in the IAFF/IAFC's *Fire Service Joint Labor Management Wellness/Fitness Initiative* [IAFF, IAFC 2000], and in the National Volunteer Fire Council (NVFC)'s *Health and Wellness Guide* [United States Fire Administration (USFA) 2004]. Given the structure of the affected Fire Department, the NVFC program might be the most appropriate model. NIOSH recommends a formal, structured wellness/fitness program to ensure all members receive the benefits of physical exercise.

Recommendation #6: Perform an autopsy on all on-duty fire fighter fatalities.

In 1995, the USFA published the *Firefighter Autopsy Protocol* [USFA 1995]. With this publication, the USFA hopes to provide "a more thorough documentation of the causes of firefighter deaths for three purposes:

1. to advance the analysis of the causes of firefighter deaths to aid in the development of improved firefighter health and safety equipment, procedures, and standards;
2. to help determine eligibility for death benefits under the Federal government's Public Safety Officer Benefits Program, as well as state and local programs; and

3. to address an increasing interest in the study of deaths that could be related to occupational illnesses among firefighters, both active and retired."

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