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NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation *March 16, 2004*

Fire Chief Dies After Performing Service Call – Connecticut

SUMMARY

On November 18, 2002, a 50-year-old male volunteer Fire Chief responded with his fire department (FD) to a medical call, then proceeded to respond to a separate incident involving a carbon monoxide (CO) alarm at a private residence. He responded to this second incident alone and found no carbon monoxide using the department's CO detector. Upon returning to the fire station he complained to his wife by telephone of not feeling well. His wife called 911, and responding members of his department arrived shortly before he lost consciousness. Cardiopulmonary resuscitation (CPR) was begun immediately following his cardiac arrest. Despite defibrillation attempts, intubation, and advanced life support (ALS) medications, resuscitation efforts were unsuccessful. The death certificate listed "ASCVD" (atherosclerotic coronary vascular disease) as the immediate cause of death, with hyperlipidemia and smoking as contributing factors. An autopsy revealed near-total occlusion of two coronary arteries.

The following recommendations address general health and safety issues relating to line of duty deaths due to cardiovascular events in firefighters. These are preventative measures that may reduce the risk of sudden cardiovascular deaths in the fire service. These selected recommendations have not been evaluated by the National Institute for Occupational Safety and Health (NIOSH) but represent published research, consensus standards issued by the National Fire Protection Association (NFPA) and fire service labor/management fitness and wellness initiatives.

- Place and maintain automated external defibrillators (AEDs) on all fire department apparatus that are not equipped and staffed for manual defibrillation.

- Phase-in a mandatory wellness/fitness program for fire fighters to reduce modifiable risk of cardiovascular disease and improve cardiovascular capacity. Specifically address: regular exercise, weight control, smoking cessation, and low fat, low cholesterol diet.

- Phase in the recommendations of NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, regarding evaluation of cardiovascular fitness for duty.
  - ensure ability to exercise to 12 metabolic equivalents (METS) without symptoms or electrocardiographic changes of coronary artery disease (CAD)

- While likely not contributing to the outcome of the present incident, staffing patterns and procedures that prevent fire personnel from being alone on duty should be instituted.

Fire Chief Dies After Performing Service Call – Connecticut

- Autopsies performed on fire service personnel should follow the U.S. Fire Administration and U.S. Department of Justice Public Safety Officer Benefits protocols. This includes obtaining carboxyhemoglobin levels to rule out carbon monoxide exposure as a contributor to the cause of death.

INTRODUCTION AND METHODS

On November 18, 2002, a 50-year-old male Fire Chief responded with his department to an emergency medical service (EMS) alarm where he helped load a patient into the department's ambulance, and then responded alone to a residential carbon monoxide (CO) alarm. He returned to the firehouse to complete documentation of the CO detector false alarm. He called his wife complaining that he was acutely ill. She called 911, and drove to the firehouse. Firefighter/Emergency Medical Technician (EMTs) responded directly to the fire station, where the Fire Chief lost consciousness on their arrival. He had no pulse. Appropriate Basic Life Support (BLS) including CPR was initiated immediately, soon followed by ALS, but the patient never regained consciousness or pulses. NIOSH was notified of this fatality on November 18, 2002.

On February 14, 2003, two contractors with the NIOSH Fire Fighter Fatality Investigation Program traveled to Connecticut to conduct an on-site investigation of the incident.

During the investigation NIOSH contractors interviewed the:

- Current Fire Chief, the Fire Chief's twin brother
- Fire fighter/EMTs (including another brother of the Fire Chief) who responded to the firehouse and found the Chief
- Dispatcher who took the 911 call from the wife
- Responding ambulance service personnel and paramedic
- President of the Fire Company
- FD physician who also served as the Fire Chief's personal physician

During the site visit NIOSH contractors reviewed the following:

- FD training records
- FD Standard Operating Guidelines
- Past medical records of the deceased
- Ambulance and paramedic run reports
- National Fire Incident Reporting System (NFIRS) reports
- Transcript of radio communications associated with incident
- Death certificate, autopsy records

INVESTIGATIVE RESULTS

Incident. On November 18, 2002, at 1528 hours, a medical call requiring BLS transport was received, and four firefighter/EMTs (including the deceased who was also Chief of the department) responded. At 1550 hours, the Fire Chief was assisting the others loading the patient into their ambulance when another call requiring CO monitoring was received. The Chief returned to the firehouse to obtain the CO gas metering equipment, and proceeded alone to the private residence. The department had responded to the same address the previous day for the same reason. The Chief cleared that call at 1610 hours, but it is unknown what time he returned to quarters. Upon returning to the firehouse, the Chief documented the monitor's findings, and called his wife, complaining of difficulty breathing. She called 911 at 1639 hours and relayed this information. The FD, a paramedic covering the town from the local hospital, and a mutual aid ambulance from a neighboring town were dispatched at 1640 hours. At 1642 hours the Fire Chief's wife radioed the FD that she was also en route to the station, but received no answer. Dispatch acknowledged the responding ambulance and paramedic at this time. Within minutes,

the first officer, and firefighter/EMT from the Chief's own department, arrived. The Fire Chief was sitting on the ground against the wall under the telephone he had used to summon help. He was wearing a non-rebreather mask and receiving 100% oxygen that he had self-administered. He was noted to be cyanotic but not sweating. The Chief said a few words and lost consciousness. He had no pulse, and by 1650 hours responding personnel began CPR. Other firefighter/EMTs, including the Chief's twin brother who was deputy chief, had arrived. No AED was available in the firehouse, as the department's ambulance had not yet returned from the previous call and the fire engine in the apparatus bay was not equipped with an AED.

The mutual aid BLS ambulance arrived at the firehouse at 1654 hours. Three shocks were given. A paramedic arrived at 1655 hours and a fourth shock was given. The patient was noted to be very cyanotic in the upper body. By 1657 hours they were en route to the hospital; the Chief was intubated and ALS medications given. The ambulance arrived at the Emergency Department (ED) at 1713 hours. The Chief had pulseless electrical cardiac activity upon arrival in the ED. He received several further rounds of ALS medications, but never regained spontaneous circulation. He was pronounced dead at 1736 hours.

Medical Findings. The death certificate was completed by the assistant medical examiner. "ASCVD", or atherosclerotic coronary vascular disease, was listed as the immediate cause of death, and "hyperlipidemia" and "smoking" as contributing factors. In addition, "very strong family history ASCVD" was listed as contributing to the cause of death. An autopsy revealed arteriosclerosis, with 95% occlusion of the left main coronary artery and 90% occlusion of the right coronary artery. Early myocardial necrosis was seen in the left ventricle, and this suggested cardiac muscle death of less than two hours duration. His lungs showed marked acute congestion that was considered to be not more than a few hours old, as well. No CO level was done at autopsy.

The Fire Chief did not have known CAD, but had the following five CAD risk factors: age greater than 45 years, male gender, strong family history of heart attacks and sudden cardiac death at a young age, hyperlipidemia, and smoking. His family history included a twin brother who had a myocardial infarction (MI) and coronary artery bypass grafting (CABG) before age 40. In addition, their father died of MI at 43 years of age.

The Chief's first exercise stress testing (EST) was in 1991, performed due to his multiple risk factors for CAD. No abnormalities were seen. He presented five months later with chest pain suggestive of ischemia, elevated cardiac enzymes (suggestive of a heart attack), and underwent cardiac catheterization which was negative for blockages in his coronary arteries. Repeat exercise stress tests in 1994, 1996, 1997, 1998, 2000 (two ESTs), and in January of 2002 were interpreted as negative with heart rates that achieved or approximated age-adjusted maximal values. He exercised to 10 or 12 METS on each test. He reached 10 METS on his Jan 2002 EST.

The Chief had his last annual physical exam on October 11, 2002. He was advised to lose weight, stop smoking, and continue seeing his cardiologist twice a year. An electrocardiogram (EKG) done in October showed no acute signs of ischemia, but had decreased voltage when compared to an EKG done in 1996. He had high serum cholesterol levels diagnosed in 1991 and treatment with a lipid lowering medication was begun in 1998. Recent cholesterol levels were normal.

The Chief had lost weight according to physician recommendations. Other than continuing to smoke,

he was generally compliant with medical regimens and follow-up. Besides his work as a volunteer fire chief, he had recently retired from a desk job. On the day of the incident, he had been out hiking in preparation for the hunting season, and did not complain of any symptoms such as chest pain, fatigue or shortness of breath. He did not appear to be ill or in any distress while assisting at the medical call where he was last seen prior to his collapse.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the FD protected a geographic area of 40 square miles and a population of 4,107 town residents. In addition, the FD provided their ambulance for mutual aid to a neighboring town of 29 square miles and 1,617 residents. At the time of the incident, the FD consisted of 30-35 active volunteer personnel.

The FD has two fire stations, and two volunteers take call duty from 2300-0500 daily. Each fire station has two engine-tankers; one at each station carries pneumatic extrication tools. The ambulance is based at the station where the Fire Chief became symptomatic.

In the latter six months of 2002, the FD responded to 236 calls: 165 medical calls and 71 fire calls (structure fires, vehicle fires, dumpster fires, grass/brush fires, mutual aid fires, other fires). For the fiscal year prior to that, the FD responded to 418 calls, 294 medical and 124 fire calls. On the day prior to the incident, the Fire Chief responded to 5 service calls for wires/trees down and one medical call. On the day of the incident, the Chief responded to one early morning medical call and the medical call immediately prior to the CO alarm.

Training. The Fire Department requires that all active interior structural fire fighters be state-certified to the Fire Fighter I level. There is no state requirement for recertification of firefighters. The Fire Chief was a state-certified Fire Officer and Instructor, an EMT, had been Chief for 5 years, and had 30 years of volunteer firefighting experience. He had multiple training certificates in many aspects of firefighting including Hazardous Materials response.

Pre-placement Evaluations. Volunteers and paid personnel are required to have a pre-placement comprehensive medical exam prior to active duty, regardless of age. The fire fighter's personal physician performs the examination and determines the content. The FD provides a "physical and respirator clearance" form, essentially a focused review of systems. Physical ability tests are not required.

Periodic Evaluations. No periodic medical evaluations are required. If employees are injured or have a medical illness, clearance to return to work by the FF's personal physician is required. Neither exercise equipment nor specific FD fitness/wellness programs were in place at the time of this incident.

The Fire Chief was last medically evaluated by his private physician in October 2002, and by his cardiologist in January 2002.

DISCUSSION

In the United States, coronary artery disease (CAD) is the most common risk factor for cardiac arrest and sudden cardiac death.[1] The Fire Chief had no known CAD, but was at increased risk for development of CAD due to his strong family history, smoking, hyperlipidemia, age over 45, and male gender. Other risk factors for the development of CAD which the Chief did not have includes high blood pressure, obesity, physical inactivity, and diabetes.[2,3]

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.[4] This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques after disruption of these plaques. Although the deceased did not have a blood clot on autopsy, he probably suffered a heart attack as evidenced by severe occlusive atherosclerotic disease in his left main and right coronary artery, 95% and 90% respectively. His autopsy findings of heart muscle death of less than two hours duration and his clinical scenario, further support the case for a heart attack leading to his sudden cardiac death.

Certain characteristics of the plaques (size, composition of the cap and core, presence of a local inflammatory process) predispose the plaque to disruption.[4] Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate, increased catecholamines, and shear forces, which can occur during heavy exercise.[5,6] Epidemiologic studies have found that physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[10-13]

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.[7] Although the Chief had not been on a fire call within the previous 24 hour period, he had responded to several emergency calls. Simply responding to an alarm causes an immediate increase in heart rate which in turn, increases the amount of work required of the heart.[8] Even when energy costs are moderate (as measured by oxygen consumption) and work is performed in a thermo-neutral (neither hot nor cold) environment, heart rates may be high (over 170 beats per minute) owing to the insulative properties of the personal protective clothing.[9]

The NFPA has developed and revised guidelines for FD physicians entitled "Standard on Comprehensive Occupational Medical Programs for Fire Departments", also known as NFPA 1582.[14] The Chief and his physician followed NFPA 1582's 2000 guidelines appropriately; he underwent initial exercise stress testing at age 40, which is also when his very strong family history became evident.[15] He continued to be tested approximately every two years. The 2000 edition of NFPA 1582 recommended annual medical evaluations with EKG's for all incumbent firefighters, and suggested that exercise stress testing (EST) should be performed at age 35 if one or more CAD risk factors are present. Appendix A goes on to define acceptable exercise tolerance as >10 METS. The Chief had exercised to 10 METS within the last two years and to 12 METS in March 2000.

Although this FD does not require annual medical exams or screening EST, the Fire Chief did undergo close medical and cardiac monitoring by his internist and cardiologist. NFPA 1582 was revised in 2003 to require stress testing as clinically indicated by history or symptoms. Evaluation of specific medical conditions are clarified within the Standard, rather than as an Appendix. Exercise tolerance of <12 METS in a patient with CAD may "compromise a member's ability to safely perform" a number of essential job tasks associated with firefighting.[14] The Chief had multiple ESTs over a ten year period, the last being 11 months prior to his death. The fact that none of these ESTs identified his underlying CAD reflects one limitation of the EST as a CAD screening test (i.e., false negative results).[16] This case may represent an example of a firefighter who despite not having a diagnosis of CAD was appropriately followed closely by a cardiologist because of his risk factors. It is not known whether use of the more demanding requirements outlined in the 2003 revision of NFPA 1582 (12 versus 10 METS) would have led to earlier detection of the Chief's CAD.

RECOMMENDATIONS

The following recommendations generally address fire fighter health, safety and fitness for duty. This list includes some preventative measures that have been recommended by other agencies to reduce the risk of line-of-duty heart attacks and sudden cardiac death among fire fighters. These recommendations have not been evaluated by NIOSH, but represent research presented in the literature or consensus votes of Technical Committees of NFPA, labor/management groups within the fire service, or the American Heart Association.

Recommendation #1. Place and maintain automated external defibrillators (AEDs) on all fire department apparatus that are not equipped and staffed for manual defibrillation.

Responding BLS personnel must have full BLS equipment available in order to provide care to the full extent of their training. In this case, there was an engine-tanker in the apparatus bay that had some emergency medical equipment on board. The FD's only AED, however, was on the ambulance that had not yet returned from the previous medical call. The Fire Chief had retrieved an oxygen cylinder and a non-rebreather mask from his own vehicle, and was receiving 100% oxygen when the first EMT's arrived on scene. When he suffered his arrhythmia with loss of his pulse, however, the responders could only perform CPR while they waited several minutes for a defibrillator to arrive. It is well known that the probability of return of pulses is highly correlated with the length of time to delivery of first shock, and prognosis deteriorates by the minute prior to defibrillation.[17]

Both because of the value to the citizens protected by a fire department providing EMS, and because of the risk of sudden cardiac death in fire fighters, all fire apparatus should be equipped with AEDs, and all staff should be trained to use them. Early defibrillation is an essential link in the "chain of survival" emphasized by the American Heart Association.[18,19]

Recommendation #2: Phase in a mandatory wellness/fitness program for fire fighters to reduce modifiable risk of cardiovascular disease and improve cardiovascular capacity. Specifically address:

-regular exercise
-weight control
-smoking cessation
-low fat, low cholesterol diet

The International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) created the Fire Service Joint Labor Management Wellness/Fitness Initiative to strengthen fire fighters' mental, physical, and emotional capabilities.[20] NFPA 1583 Standard on Health-Related Fitness for Firefighters prescribes similar department-wide programs to enhance physical fitness and reduce modifiable cardiac risk factors in firefighters.[21] Both documents stress the importance of regular aerobic and strengthening exercise, nutrition and weight control, and smoking cessation.

Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.[22,23] A similar cost savings has been reported by the wellness program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.[24]

Despite the absence of an organized fitness/wellness program in this fire department, the Fire Chief had been generally compliant with his medical program of risk reduction. He took cholesterol lowering medication and had a normal serum lipid profile on his recent medical evaluation. He was physically active, as evidenced by his hiking earlier on the day of his death, and had lost weight when asked to do

so by his physician. He had not been able to stop smoking.

Recommendation #3: Phase in the recommendations of NFPA 1582 Standard on Comprehensive Occupational Medical Programs for Fire Departments regarding evaluation of cardiovascular fitness for duty. (Ensure ability to exercise to at least 12 METS without symptoms or electrocardiographic changes).

NFPA 1582 includes very specific guidelines for interpretation of cardiac tests and diagnoses. Firefighters must be able to exercise to 12 METS rather than just exercising to a high percentage of an age-predicted maximal heart rate.[14] Although the Fire Chief exercised to maximal or near-maximal heart rate on each stress test, he had not recently exceeded 10 METS on his EST. Fitness levels or exercise capacity equivalent to 14 METS have been recommended for active firefighters.[25]

Recommendation #4: While likely not contributing to the outcome of the present incident, staffing patterns and procedures that prevent fire personnel from being alone on duty should be instituted.

NFPA standards[18,26] and OSHA[27] regulations emphasize the need for adequate staffing to safely engage in fire suppression and emergency medical response under all conditions. Especially in small, volunteer fire departments, individual officers or firefighters may sometimes respond unaccompanied to calls that are considered low hazard, and may therefore be alone in apparatus or fire stations when they are involved in a vehicle collision or suffer a medical emergency. This can negatively impact the ability of the local department to detect the emergency and render assistance in a timely fashion.

The present case represents the second instance in a two-year period where two neighboring towns have had fire personnel suffer catastrophic illness while alone in a fire station.[28] While it is difficult to predict alternative outcomes in either case, there was certainly a delay in initiation of care and resuscitation that resulted from the personnel being on duty alone.

Recommendation #5: Autopsies performed on fire service personnel should follow the U.S. Fire Administration and U.S. Department of Justice Public Safety Officer Benefits protocols.[29,30] This includes obtaining carboxyhemoglobin levels to rule out carbon monoxide exposure as a contributor to the cause of death.

In this case, it is unlikely that carbon monoxide exposure contributed to the Fire Chief's cause of death. He was, however, a smoker and had recently responded to a report of a residential CO alarm sounding. The residence was appropriately metered and found not to have elevated CO levels, so the chief was probably not exposed on that call.

This fact should not preclude hospital staff and medical examiners from following the full autopsy protocol when investigating a line-of-duty death of a firefighter. CO is not only a threat in cases of smoke inhalation and malfunctioning heating systems. Fire service personnel may also be exposed through less apparent ways, such as faulty exhaust systems in personal vehicles or FD apparatus, or by inhaling exhaust in apparatus bays or other enclosed spaces. The presence of carboxyhemoglobin in blood would certainly exacerbate CAD that might otherwise be sub-critical, and needs to be documented as part of the post-mortem examination of firefighters.

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INVESTIGATOR INFORMATION

This investigation was conducted and the report written by Carin Van Gelder, MD, and Sandy Bogucki, MD, PhD. Mrs. Van Gelder and Bogucki conducted this investigation under contract with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component.