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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 *November 7, 2005*

Fire Chief Suffers Sudden Cardiac Death at Home After Performing Apparatus Maintenance and Conducting Training – Texas

SUMMARY

On February 22, 2005, a 39-year-old male volunteer Fire Chief performed apparatus maintenance on two fire department (FD) vehicles, conducted traffic control and hazardous materials classroom training, and demonstrated the force required to pull a box of extrication tools out of an apparatus compartment. Later that evening, he complained of "stomach discomfort." On February 23, 2005, the Chief pulled the extrication tool box out again to verify its contents. After going home and preparing to retire for the evening, his stomach disco mfort became more severe. His wife, a fire fighter/emergency medical technician (FF/EMT), prepared to call 911 but the Chief wanted to be driven to the hospital. As the Chief was getting dressed, he collapsed (2358 hours). His wife found him unresponsive, not breathing, but with a pulse. She cleared his airway, called 911, and began rescue breathing. The Chief soon became pulseless, and she began cardiopulmonary resuscitation (CPR). FD units and an ambulance were dispatched and provided advanced life support (ALS). Despite CPR and ALS performed by FD crew members, ambulance service paramedics, and hospital emergency department (ED) personnel, the Chief died. The death certificate, completed by the Justice of the Peace, and the autopsy, completed by the forensic pathologist, both listed "severe three vessel atherosclerotic coronary artery disease" (CAD) as the cause of death. The NIOSH investigator concluded that the physical stress of performing apparatus maintenance, conducting training, and the Chief's underlying atherosclerotic CAD contributed to his sudden cardiac death.

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

Provide pre-placement and annual medical evaluations to ALL fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Provide fire fighters with medical evaluations and clearance to wear SCBA.

Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

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

Use a secondary (technological) test to confirm appropriate placement of the endotracheal (ET) tube during emergency intubations.

INTRODUCTION & METHODS

On February 23, 2005, a 39-year-old male Fire Chief suffered sudden cardiac death at home after performing equipment checks at his fire station. Despite CPR and ALS performed by his spouse, FD crew members, ambulance service personnel, and hospital ED personnel, the Chief

Fire Chief Suffers Sudden Cardiac Death at Home After Performing Apparatus Maintenance and Conducting Training – Texas

died. NIOSH was notified of this fatality on March 10, 2005, by the United States Fire Administration. NIOSH contacted the affected FD on March 18, 2005, to obtain further information, and on August 12, 2005, to initiate the investigation. On September 12, 2005, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation and Prevention Team traveled to Texas to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel met and/or interviewed the following people:

- Current Fire Chief
- Assistant Chief
- Crew members
- Chief's wife

During the site visit NIOSH personnel reviewed the following documents:

- FD incident report
- FD training records
- FD standard operating guidelines
- FD annual response report for 2004
- Witness statements
- Primary care physician records
- Ambulance report
- Hospital ED report
- Death certificate
- Autopsy report

INVESTIGATIVE RESULTS

On February 22, 2005, the Fire Chief worked his regular job installing bank equipment. After getting off work at 1700 hours, he went to the fire station to conduct training that evening. The training, which began at about 1900 hours, consisted of classroom work on hazardous materials and traffic control. After the Chief had finished his portion, he went into the apparatus bay to perform truck maintenance. He repaired a water leak under the tanker, changed the rotor on the front of the utility truck, greased the pump and valve levers on the engine, and pulled out the extrication tool box, weighing about 300 pounds, to inspect the tools. The Junior Fire Fighters had been using the tools earlier, and the Chief wanted to verify that all the tools were accounted for and in good working order. He was also going to install wheels under the box for easier removal from the truck. During this time the Chief also climbed 16 steps to the second floor at least six times to retrieve tools and equipment. At the station he began rubbing his stomach and related to his wife that his stomach didn't feel right. They left for home at about 2300 hours.

On February 23, the Chief arose at 0500 hours and went to his regular job where he helped install an automated teller machine at a bank. At 1700 hours, the Chief left work and went to the fire station. After pulling the 300 pound extrication tool box out of the truck and checking the self-contained breathing apparatus (SCBAs), he and his wife went to a local café for coffee. While at the café, he related that his stomach had been bothering him all day, which he now described as a "gas bubble." After running an errand, he returned home to work on some deck lights for about an hour. His stomach discomfort continued, and his wife asked him if he wanted to go to the doctor. He declined, and they went to bed at about 2230 hours.

At about 2330 hours, the Chief's wife awoke to find him standing in the doorway complaining of worse stomach pain and a new pain between his shoulder blades. His wife began to call 911, but the Chief insisted she drive him to the hospital. After an episode of vomiting, the couple prepared to drive to the hospital (2345 hours). As his wife retrieved her purse and keys, the Chief collapsed onto the floor and appeared to be vomiting again. She turned his head to the side, cleared his airway, and called 911 (2358 hours). She then log-rolled him over onto his back where he began agonal breathing. At this point the Chief was unresponsive but had a pulse, and she began rescue breathing. His wife called 911 again to request an ambulance, then continued rescue breathing. At this point the Chief stopped breathing, and she began CPR.

After one full round of CPR, the Chief regained a pulse, took a breath, made a moaning sound, opened his eyes and looked at his wife, then stopped breath-

Fire Chief Suffers Sudden Cardiac Death at Home After Performing Apparatus Maintenance and Conducting Training – Texas

ing again. His wife started CPR again and continued until a First Responder (FR) arrived (0003 hours). Finding the Chief unresponsive, with no pulse and no respirations, and CPR in progress, the FR analyzed the Chief's heart rhythm with an automated external defibrillator (AED). Five shocks (defibrillation attempts) were delivered. Another FR arrived to assist and called 911 to inquire of the whereabouts of the ambulance.

The ambulance arrived on the scene at 0012 hours. Paramedics found the Chief unresponsive, pulseless, and apneic (not breathing) with CPR in progress. A cardiac monitor was attached to the Chief. It revealed ventricular fibrillation (Vfib), and two shocks were administered. After the last shock, his heart rhythm reverted to asystole (no heart beat) and CPR continued.

The Chief was intubated (a breathing tube inserted into the trachea), and an intravenous (IV) line was placed. Lung sounds were confirmed with bilateral auscultation and fogging of the tube, but no secondary confirmation techniques (carbon dioxide or bulb) were used. After cardiac resuscitation medications and two more shocks were administered, he was placed onto a backboard and stretcher and loaded into the ambulance. The ambulance left the scene en route to the hospital at 0029 hours.

At 0042 hours, the ambulance arrived at the hospital's ED. At this point the Chief had been in cardiopulmonary arrest for over 40 minutes. ALS resuscitation measures continued in the hospital's ED for an additional 23 minutes without an improvement in the Chief's condition. At 0105 hours, the attending physician pronounced the Chief dead, and resuscitation measures were discontinued.

Medical Findings. The death certificate, completed by the Justice of the Peace, listed "severe three vessel atherosclerotic heart disease" as the cause of death. The autopsy, completed by the forensic pathologist, listed "severe three vessel CAD" as the cause of death. The autopsy, performed on February 24, 2005, included the following findings:

- Atherosclerotic CAD:
  - Three vessel focal severe atherosclerotic CAD
  - Right ventricle chamber mildly dilated
- Cardiomegaly (enlarged heart): heart weighed 460 grams (normal < 400 grams)[1]
- No pulmonary embolism
- No evidence of a dissecting aortic aneurysm

The Chief had not been to a physician in several years and was asymptomatic prior to this episode. His only modifiable risk factor for CAD was smoking.

At autopsy, the Chief weighed 180 pounds and was 68 inches tall, giving him a body mass index (BMI) of 27.3 kilograms per square meter (kg/m^2). A BMI 25 kg/m^2 to 29 kg/m^2 is considered overweight[2]. According to the Chief's wife, the Chief did not perform regular strenuous exercise, but remained very active and went to work every day.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this volunteer FD consisted of 30 uniformed personnel, served a population of 7,500 in a 93 square mile-area, and had one fire station.

In 2004, the FD responded to 221 calls including the following: 28 structure fires, 22 vehicle fires, 33 wildland fires, 40 motor vehicle accidents, 14 hazardous materials calls, 23 assistance calls, 15 alarm calls, 27 landing zone calls, 12 traffic control calls, 3 burn ban calls, 2 mutual aid calls, 1 train derailment, and 1 pipeline call.

Training. The FD requires all fire fighter applicants to possess a valid state driver's license and fulfill a 6-month probationary period that includes training on all apparatus, equipment, and radio procedures. The candidate must also attend business meetings, emergency responses, and other FD functions. At the end of 6 months, the candidate is voted onto the FD

Fire Chief Suffers Sudden Cardiac Death at Home After Performing Apparatus Maintenance and Conducting Training – Texas

by a simple majority of members. The voluntary State minimum requirement for fire fighter certification is the 468-hour Fire Fighter I and II course and the 40-hour Emergency Care Attendant course.

Annual recertification is required for hazardous materials while Emergency Medical Technician and Paramedic recertification is biannual.

The Chief was certified as Incident Commander, Incident Safety Officer, State Fire Fighter, and in Hazardous Materials Operations. He had 8 years of fire fighting experience.

Pre-placement and Periodic Evaluations. No pre-placement or periodic physical examinations are required by this FD because of the cost. However, all applicants are required to complete a medical history form that is reviewed by a medical first responder and the Fire Chief, who makes the final determination for fitness for duty. No physical agility test is required by this FD. There is no wellness/fitness program and no exercise equipment is available for use. A return-to-duty medical clearance is required for injuries that prevent fire fighters from performing their duty. The member's primary care physician provides the clearance, which is forwarded to the Fire Chief, who makes the final determination for return-to-duty. Annual SCBA fit tests are conducted by the FD.

DISCUSSION

Coronary Artery Disease and the Pathophysiology of Sudden Cardiac Death. In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.[3] Risk factors for CAD development include age over 45, male gender, family history of coronary artery disease, smoking, high blood pressure (systolic > 140 millimeters of mercury [mmHg] or diastolic > 90 mmHg), high blood cholesterol (total cholesterol > 240 milligrams per deciliter [mg/dL]), obesity/physical inactivity, and diabetes.[4,5] The Chief had two of these risk factors (male gender and smoking).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.[6] However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.[7] 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.[8] This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. The sequence of events of the Chief's death is consistent with, but not diagnostic of, a heart attack. Heart attacks are confirmed/diagnosed by any of the following: autopsy findings (thrombus formation), blood tests (cardiac isoenzymes), or EKG findings. The autopsy did not reveal a thrombus, the Chief died prior to the cardiac isoenzymes becoming positive, and the Chief did not have a heart rhythm on which to conduct an EKG. Therefore, based on the clinical scenario, the Chief probably had a heart attack, but this cannot be definitively stated.

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.[9] Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods.[10-12] Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[13-16] The Chief worked at his regular job the day before and the day of his collapse, moved a box of extrication tools weighing about 300 pounds on two occasions, conducted training, and performed apparatus maintenance. This activity is considered moderate physical exertion.[17,18] The physical stress of working at his regular job, moving the heavy extrication box, performing apparatus maintenance, and his underlying atherosclerotic CAD contributed to this fire fighter's cardiac arrest and sudden death.

Occupational Medical Standards for Structural Fire Fighters and Use of Exercise Stress Tests to Screen for CAD. 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*.[19] NFPA 1582 recommends that, as part of its annex for informational purposes only, screening asymptomatic fire fighters with two or more risk factors for CAD for obstructive CAD by an EST. NFPA defines these CAD risk factors as: family history of premature (first degree relative less than age 60) cardiac event, hypertension (diastolic blood pressure > 90 mmHg), diabetes mellitus, cigarette smoking, and hypercholesterolemia (total cholesterol > 240 mg/dL).[19] This guidance is similar to recommendations from the American College of Cardiology/American Heart Association (ACC/AHA) and the Department of Transportation (DOT) regarding EST in asymptomatic individuals.[20,21]

Because the Chief had only one "NFPA and DOT" CAD risk factor (smoking), an EST would not have been recommended by either of these organizations. While a mandatory comprehensive wellness/fitness program, including smoking cessation, dietary education, and exercise would have benefited this fire fighter, it is unclear if that alone would have prevented his death at this time.

RECOMMENDATIONS

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

Recommendation #1: Provide pre-placement and annual medical evaluations to ALL fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Guidance regarding the content and frequency of pre-placement and periodic medical evaluations and examinations for structural fire fighters can be found in NFPA 1582,[19] in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) *Wellness/Fitness Initiative*,[22] and the National Volunteer Fire Council (NVFC) *Health and Wellness Guide*.[23] The FD is not legally required to follow any of these standards.

Applying this recommendation involves economic repercussions and may be particularly difficult for small, rural, volunteer fire departments to implement. To overcome the financial obstacle, the FD could urge current members to get annual medical clearances from their private physicians. Another option is having the annual medical evaluations recommended by NFPA 1582 completed by other members of the volunteer FD (medical and occupational history) and by EMTs from the county's emergency medical service (vital signs, height, weight, visual acuity, EKG). This information could then be provided to a community physician, perhaps volunteering his or her time, to review the data and provide medical clearance (or further evaluation, if needed). The more extensive portions of the medical examinations could be performed by a private physician at the fire fighter's expense, provided by a physician volunteer, or paid for by the FD. Sharing the financial responsibility for these evaluations between volunteers, the FD, and physician volunteers may reduce the financial impact on recruiting and retaining needed volunteers. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, Chapter 8-7.1 and 8-7.2[24] and the NVFC *Health and Wellness Guide*[23] address these issues.

Recommendation #2: Provide fire fighters with medical evaluations and clearance to wear SCBA.

The Occupational Safety and Health Administration's (OSHA) Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection.[25] Such employees include fire fighters who utilize SCBA in the performance of their duties. These clearance evaluations are required for private industry employees and public employees in states operating OSHA-approved State plans. Texas is not a state-plan state, therefore, public sector employers are not required to comply with OSHA standards. However, we recommend voluntary compliance and have pro-

Fire Chief Suffers Sudden Cardiac Death at Home After Performing Apparatus Maintenance and Conducting Training – Texas

vided the FD with a copy of the OSHA-approved respiratory protection clearance form.

Recommendation #3: Phase in a mandatory 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.[26] NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[24] NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*, provides guidance for a health-related fitness program.[27]

In 1997, the IAFF and the IAFC published a comprehensive *Fire Service Joint Labor Management Wellness/Fitness Initiative* to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual and a video detailing elements of such a program.[22] Large-city negotiated programs can also be reviewed as potential models. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.[28-30] 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.[31] The NVFC *Health and Wellness Guide* addresses wellness/fitness programs as they relate to volunteer fire departments.[23]

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 fire fighting.

NFPA 1500 requires fire department members who engage in emergency operations to be annually evaluated and certified by the fire department as meeting the physical performance requirements identified in paragraph 8-2.1.[24]

Recommendation #5: Use a secondary (technological) test to confirm appropriate placement of the endotracheal (ET) tube during emergency intubations.

To reduce the risk of improper intubation, the American Heart Association and the International Liaison Committee on Resuscitation published recommendations in the Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.[32] These guidelines recommend confirming tube placement by primary and secondary methods. Primary confirmation is the 5-point auscultation: left and right anterior chest, left and right midaxillary, and over the stomach. Secondary confirmation requires a technology test, either an end-tidal carbon dioxide detector or an esophageal detector device. In this incident, the Chief had bilateral breath sounds confirmed by auscultation and the tube became visibly fogged, however, according to records obtained by the NIOSH investigator, secondary confirmation was not performed. In no way should this recommendation imply that improper placement of the ET contributed to the Chief's death. We raise this issue only to ensure that future ALS resuscitation efforts follow AHA guidelines.

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