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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 *August 24, 2005*

Fire Chief Suffers Sudden Cardiac Death After Responding to a Motor Vehicle Crash – Texas

SUMMARY

On October 20, 2004, a 58-year-old male career Fire Chief responded to a motor vehicle crash (MVC). After assisting with traffic control for about 30 minutes and with other operations for about 20 minutes, he went home. About three hours later, while taking a shower, the Chief collapsed. When discovered by his wife a minute later, he was unresponsive, but still breathing. She called 911 and an ambulance was dispatched. Despite cardiopulmonary resuscitation (CPR) and advanced life support (ALS) performed by fire department (FD) crew members, ambulance service paramedics, and hospital emergency department (ED) personnel, the Chief died. The death certificate, completed by the attending physician, listed "arrhythmia" as the cause of death due to "coronary artery disease" (CAD) with "atrial fibrillation and sleep apnea" as other significant conditions. No autopsy was performed. The NIOSH investigator concluded that the physical stress of responding to the MVC, the Chief's underlying arteriosclerotic CAD, and his history of atrial fibrillation and sleep apnea 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.

Consider conducting periodic exercise stress tests for male fire fighters over the age of 45 years with two or more risk factors for coronary artery disease.

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

***Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582,* Standard on Comprehensive Occupational Medicine Program for Fire Departments.**

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.

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 Web site at

www.cdc.gov/niosh/firehome.html

Fire Chief Suffers Sudden Cardiac Death After Responding to a Motor Vehicle Crash – Texas

Perform an autopsy on all on-duty fire fighter fatalities.

INTRODUCTION & METHODS

On October 20, 2004, a 58-year-old male Fire Chief suffered sudden cardiac death after returning home from a MVC response. Despite CPR and ALS performed by FD crew members, ambulance service personnel, and hospital ED personnel, the Chief died. NIOSH was notified of this fatality on November 2, 2004, by the United States Fire Administration. NIOSH contacted the affected FD on November 2, 2004, to obtain further information, and on March 7, 2005, to initiate the investigation. On March 21, 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
- FD Compliance Officer
- Wife of the Chief involved in this incident

During the site visit NIOSH personnel reviewed the following documents:

- FD incident report
- FD training record
- FD standard operating guidelines
- FD annual response report for 2004
- Primary care physician (PCP) records
- Ambulance report
- Hospital ED report
- Death certificate

INVESTIGATIVE RESULTS

On October 20, 2004, the Fire Chief worked his normal 10 hour day (0700 hours to 1700 hours), performing administrative functions but no emergency responses. He left for home at about 1700 hours and went to church a short while later. At 1805 hours, while the Chief was at church eating dinner, the FD was dispatched to a MVC. The Chief, Assistant Chief (AC), Engine 1, Rescue 1, and Medic 2 responded. On the scene, the Chief performed traffic control while other personnel were involved with patient care. The accident victims were transported to the hospital and FD units cleared the scene at 1923 hours. According to witnesses, the Chief "appeared pale, was breathing a little hard, and sweating."

The Chief arrived at home at about 1930 hours. He was still sweating but was not complaining of any heart-related symptoms. After relaxing awhile, he took a shower at about 2230 hours. About 3 minutes later, his wife heard the soap drop in the shower. Sensing something was wrong, she asked him about dropping the soap but did not receive a reply. She opened the shower curtain to find the Chief collapsed on the floor of the shower. He was unresponsive, but still breathing. She called 911 (2233 hours) and an ambulance was dispatched (2234 hours). Medic 1 (2 paramedics) and the AC arrived on the scene at 2239 hours. The AC notified Dispatch to send Engine 1 for assistance.

Paramedics found the Chief unresponsive, pulseless, and apneic (not breathing). Emergency response personnel had difficulty moving the Chief from the tub to the bathroom floor due to his size (very obese) and the configuration of the bathroom. Once on the floor, a cardiac

monitor was attached to the Chief which revealed ventricular fibrillation (Vfib). Three shocks were administered via the automated external defibrillator (AED) mode. His heart rhythm was assessed between each shock and a shockable rhythm was found. After the last shock, his heart rhythm reverted to asystole (no heart beat) and CPR was begun.

An oral airway was placed and oxygen was administered but vomiting occurred. After suctioning, two attempts at intubation (a breathing tube inserted into the trachea) were unsuccessful. An intravenous (IV) line was placed and the Chief was intubated with a Combitube. (The Combitube is a dual lumen tube with two balloon cuffs which can either be inserted in the trachea or the esophagus to effect adequate ventilation). Lung sounds were confirmed with bilateral auscultation.

Cardiac resuscitation medications were administered, but his heart rhythm remained in asystole. He was placed onto a backboard and external cardiac pacing was attempted with capture at 90 beats per minute (bpm) at 140 milliamps (MA). Additional cardiac resuscitation medications were administered with no change in the Chief's heart rhythm. Cardiac pacing was lost and re-attempted at 160 MA with probable capture at a rate of 30 bpm. Unfortunately, cardiac pacing was lost again with no re-capture. After 40 minutes of resuscitation efforts, the Chief was placed into the ambulance and transported to the hospital at 2319 hours.

At 2325 hours, the ambulance arrived at the hospital's ED. ALS resuscitation measures were continued including additional cardiac resuscitation medications and oral intubation. Bilateral breath sounds were confirmed by auscultation. Despite CPR and ALS for over 60 minutes in the Chief's home, in the ambulance, and in the ED, there was no change in patient status. At 2343 hours, the attending physician pronounced the Chief dead and resuscitation measures were discontinued.

Medical Findings. The death certificate, completed by the attending physician, listed "arrhythmia" as the cause of death due to "coronary artery disease" (CAD) with "atrial fibrillation and sleep apnea" as other significant conditions. No autopsy was performed.

The Chief had been diagnosed with high blood pressure, high blood cholesterol, severe sleep apnea, and had a family history of CAD. His high blood pressure and high cholesterol were well controlled with prescription medication. His sleep apnea was being treated with a continuous positive airway pressure mask at night.

In July 2001, the Chief reported several episodes of exertional chest discomfort resulting in a stress echocardiogram test. The Chief exercised for 8 minutes, 18 seconds using the Bruce protocol[1] achieving a work level of 7.8 metabolic equivalents (METS) and a maximum heart rate of 149 beats per minute (bpm) (90% of the maximal age-predicted heart rate). The test was discontinued when 90% of calculated maximum heart rate was attained. His heart rate and blood pressure response to exertion were appropriate. He experienced no chest pain or shortness of breath with good exercise tolerance. The test revealed mild left atrial enlargement (4.84 [normal 1.9-4.0]), mild aortic insufficiency, mild left ventricular hypertrophy, and a normal left ventricular function with an ejection fraction (LVEF) of 60%. The Chief's cardiologist concluded the stress test was negative for inducible ischemia.

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In December 2003, an EKG revealed atrial fibrillation, which was treated with medication. In June 2004, another exercise stress test (EST) was recommended, but records available to NIOSH do not indicate the test was conducted. At a medical check up in August 2004, the Chief weighed 343 pounds and was 69 inches tall, giving him a body mass index (BMI) of 50.6 kilograms per square meter (kg/m^2). (A BMI 40 kg/m^2 and over is considered extremely obese[2]). According to the Chief's wife, the Chief did not perform regular strenuous exercise, but remained active and went to work every day.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this combination FD consisted of 77 uniformed personnel, served a population of 11,000 in a 78 square mile area, and had one fire station.

In 2004, the FD responded to 510 calls including the following: 19 structure fires, 16 rubbish/trash fires, 14 vehicle fires, 9 wildland fires, 21 other fires, 57 motor vehicle accidents, 23 extrications, 23 hazardous materials calls, 20 hazardous condition calls, 136 rescue/medical/ assist calls, 2 other rescue calls, 22 service calls, 7 standby calls, 88 false alarms, 11 good intent calls, 31 dispatched but cancelled en route calls, and 11 other calls.

Training. The FD requires all career fire fighter applicants to possess a valid state driver's license and be a State certified fire fighter, pass an oral interview, a background check, a pre-placement physical examination, and drug screening prior to being offered employment. The newly hired fire fighter is assigned to a shift, working Monday-Friday, 0700 hours to 1700 hours.

Volunteer fire fighter applicants must complete an application, attend a membership meeting, pass a background check, and be voted onto the FD by a simple majority of members. The new member then begins a training program that includes the 10-week State Basic Volunteer Fire Fighter program conducted at local fire academies and an in-house training program. The volunteer member must make 50% of the monthly in-house training sessions. 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.

Career fire fighters must be State certified within one year of employment. The State also requires a minimum of 20 hours training for recertification. Annual re-certification is required for hazardous materials; while Emergency Medical Technician and Paramedic recertification is biannual.

The Chief was certified as a Fire Officer, Incident Commander, Emergency Medical Technician, Driver Operator, Fire Investigator, Fire Service Instructor, Fire Inspector, Advanced Fire Fighter, Industrial Fire Fighter, and a Hazardous Materials Technician. He had 31 years of fire fighting experience and was a former city council member and police officer.

Pre-placement Physical Examination. A pre-placement physical examination is required by this FD for career applicants only. The contents of the examination are as follows:

- Complete medical history
- Physical examination
- Vital signs
- Urinalysis

Periodic Evaluations. No periodic medical

evaluations or physical agility test are required by this FD for budgetary reasons. There is a voluntary fitness program and exercise equipment is available at the City gym at no cost for its 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 City-contracted physician, who makes the final determination for return-to-duty. Annual self-contained breathing apparatus 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 six of these risk factors (age over 45, male gender, family history of CAD, high blood pressure, high cholesterol, and obesity).

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 ECG findings. No autopsy was performed, 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. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.[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 had controlled traffic during the MVC response which is considered light physical exertion.[17,18] While the Chief's underlying atherosclerotic CAD is the main reason for his cardiac arrest and sudden death, it is possible the physical stress of responding to the MVC could have triggered the event.

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, asymptomatic fire fighters with two or more risk factors for CAD be screened 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 greater than 90 mmHg), diabetes mellitus, cigarette smoking, and hypercholesterolemia (total cholesterol greater than 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] Since the Chief had three "NFPA" CAD risk factors (family history, hypertension, and hypercholesterolemia), an EST would have been consistent with NFPA 1582 and ACC/AHA guidance.

Although NFPA 1582 and the ACC/AHA agree that the Chief should have had an EST, they differ on when to stop the test. NFPA allows "submaximal" EST, while the ACC/AHA recommends terminating when symptoms or other adverse findings appear, rather than an arbitrary percentage of predicted maximal heart rate.[22] Stopping the test at 90% of the Chief's maximum age-predicted heart rate increases the risk of a false negative test, which is what happened in this case. In addition, the physical demands of fire fighting have been shown to exceed 12 METS, well above the 7.8 METS the Chief achieved on his EST.[19]

An EKG in December 2003 revealed atrial fibrillation, which was treated with medication. However, an EKG in June 2004 also revealed atrial fibrillation. The Chief was being treated with full dose anticoagulation medication. NFPA 1582 considers this to be a precluding factor for unrestricted fire fighting due to requirements of climbing ladders, working on elevated surfaces, and working near electrical power lines.[19] The Chief was diagnosed with severe sleep apnea in May 2004. NFPA 1582 identifies sleep apnea as a "disorder of respiratory regulation that can result in gas exchange abnormalities that prevent the safe performance" of fire fighting tasks, wearing an SCBA, climbing 6 or more flights of stairs while wearing turnout gear, advancing charged hoselines, and prolonged extreme physical exertion.[19]

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*,[23] and the National Volunteer Fire Council (NVFC) *Health and Wellness Guide*.[24] The FD is not legally required to follow any of these standards.

Applying NFPA 1582 involves economic issues. These economic concerns go beyond the costs of administering the medical program; they involve the personal and economic costs of dealing with

the medical evaluation results. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, Chapter 8-7.1 and 8-7.2[25] and the NVFC *Health and Wellness Guide*[24] address these issues.

The physical evaluation could be conducted by the fire fighter's primary care physician or a City/County-contracted physician. If the evaluation is performed by the fire fighter's primary care physician, the results must be communicated to the City or County physician, who should be responsible for decisions regarding medical clearance for fire fighting duties.

Recommendation #2: Consider conducting periodic exercise stress tests for male fire fighters over the age of 45 years with two or more risk factors for coronary artery disease.

NFPA 1582 and the IAFF/IAFC *Wellness/Fitness Initiative* recommend EST for fire fighters with two or more CAD risk factors.[19,23] The AHA states EST may be indicated for individuals with two or more risk factors for CAD who are over 45 years of age.[20] The EST could be conducted by the fire fighter's personal physician or the City/County contract physician. If the fire fighter's personal physician conducts the test, the results must be communicated to the City/County physician, who should be responsible for decisions regarding medical clearance for fire fighting duties.

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.[25] 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.[23] 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.[24]

Recommendation #4: Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582, Standard on Comprehensive Occupational Medicine Program for Fire Departments.

Physicians providing input regarding medical clearance for fire fighting duties should be

knowledgeable about the physical demands of fire fighting and should recognize that fire fighters frequently respond to incidents in environments that are immediately dangerous to life and health (IDLH). They should also be familiar with a FF's personal protective equipment and the consensus guidelines published by NFPA 1582.[19] To ensure physicians are aware of these guidelines, we recommend that the FD, or the FF, provide personal physicians with a copy of NFPA 1582.

If the Chief's PCP had been aware of NFPA 1582's guidance regarding anticoagulant medication, sleep apnea, and the minimum MET levels for fire fighting, perhaps he would have put the Chief on restricted duty. This may have prevented his sudden cardiac death at this time.

Recommendation #5: 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.[25]

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

In 1995, the United States Fire Administration (USFA) published the *Firefighter Autopsy Protocol*.[32] With this publication the USFA hopes to provide "a more thorough documentation of the causes of firefighter deaths for three purposes:

1. 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. 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. 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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INVESTIGATOR INFORMATION

This investigation was conducted by and the report written by:

Tommy N. Baldwin, MS
Safety and Occupational Health Specialist

Mr. Baldwin, a National Association of Fire Investigators (NAFI) Certified Fire and Explosion Investigator, an International Fire Service Accreditation Congress (IFSAC) Certified Fire Officer I, and a Kentucky Certified Fire Fighter and Emergency Medical Technician (EMT), is with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio.

U. S. Department of Health and Human Services
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
4676 Columbia Parkway, MS C-13
Cincinnati, OH 45226-1998

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