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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 22, 2006*

Assistant Chief Suffers a Stroke During Training and Dies – Texas

SUMMARY

On April 3, 2006, a 40-year-old male Assistant Chief (AC) with an industrial facility Emergency Response Team (ERT) participated in live-fire training, which included industrial fire suppression. After the training, the AC complained of not feeling well and collapsed. Crew members began first aid as an ambulance was summoned. An ambulance arrived at the site three minutes later and paramedics found the AC unconscious and unresponsive. Advanced life support was begun and the AC was transported to the hospital's emergency department (ED). Inside the ED, despite advanced life support treatment, the AC died. The death certificate (completed by the attending physician) listed "brain death due to brain aneurysm" as the cause of death. No autopsy was performed. The NIOSH investigator concluded that the AC's death was due to rupture of a cerebral aneurysm, possibly triggered by the physical exertion associated with fire suppression training. NIOSH investigators, however, cannot definitively determine whether the physical exertion played a role in his death.

The following recommendations would not have prevented this fire fighter's death. However, NIOSH investigators offer these recommendations to address general safety and health issues:

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

Discontinue routine annual electrocardiograms (EKG) unless medically indicated.

Discontinue annual screening chest X-ray unless medically indicated.

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

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

INTRODUCTION & METHODS

On April 3, 2006, a 40-year-old male AC suffered a cerebral hemorrhage (stroke) and died after performing fire suppression training. NIOSH was notified of this fatality on April 4, 2006, by the United States Fire Administration. NIOSH contacted the affected facility on April 10, 2006, to obtain further information, and on May 26, 2006, to initiate the investigation. On June 26, 2006, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Texas to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- Safety Manager
- Director, Safety and Environmental Affairs
- Facility Manager

- Occupational Health Nurse
- Crew members
- AC's wife

NIOSH personnel reviewed the following documents:

- Training center incident report
- Facility training records
- Ambulance report
- Hospital records
- Death certificate
- Primary care provider records

INVESTIGATIVE RESULTS

On April 2, 2006, the AC and two crew members from his facility's Emergency Response Team (ERT) left their hometown at about 1700 hours and drove approximately 115 miles, arriving at the training city at about 2030 hours. On April 3, 2006, the AC and his crew members arrived for training at the regional fire training facility at about 0750 hours. The ERT members participated in classroom activities from 0800 hours to 0900 hours, then donned their bunker gear for the first live-fire training evolution (Project #32 [Overhead Pipe Rack] [See photograph]).

Instructors briefed the group on safety precautions, team work and fire attack procedures. The overhead pipe rack evolution involved proper firefighting techniques to safely control and extinguish fires in and around industrial pipe racks. The demonstration included a flammable liquid containment spill of 2,000 square feet of diesel and 8-10 inches of gasoline fuel, elevated pressurized flammable liquid fire, flammable liquid run down (spill) from a vertical vessel, and liquefied petroleum gas. The project simulated a platform or walkway similar to those found in a refinery, chemical process unit, or a loading rack/terminal. Suppression tasks included cooling the structure and controlling, approaching, and extinguishing the multi-fueled pipe rack fire.

The group divided into two teams of 6-8 members each. Each member wore full bunker gear and a 30-minute self-contained breathing apparatus (SCBA) on-air (entire ensemble weighing about 50 pounds). Team 1 performed the training evolution from 0915 hours to 0935 hours while Team 2 (including the AC) observed. Team 2 (the team leader [the AC], a Safety Officer, and four fire fighters) prepared for their training evolution from 0935 hours to 0950 hours and performed the training from 0950 hours to 1013 hours. Weather conditions at this time included an outside temperature of 73º Fahrenheit (º F) and 79% relative humidity.

Team 2 began the evolution by advancing the charged 1½-inch hoseline toward the fire. The AC initially served as the #2 person on the hoseline, responsible for closing the fuel valve. The crew member on the nozzle experienced SCBA problems and the AC assumed the nozzle position. After about 10 minutes on the structure, the crew extinguished the fire without any further problems and assembled at the rest house shelter for rehab. The AC removed his SCBA, opened his bunker coat, and sat on a bench. A crew member asked him if he was okay. The AC looked at the crew member and laid back onto the bench. The

AC related to the ERT Fire Chief that he "really did not feel well."

The Chief notified the training facility instructor who summoned the on-site field paramedics. Other ERT members removed the remainder of the AC's bunker gear, applied cool towels, and began administering first aid (1016 hours). Paramedics began advanced life support treatment including intravenous (IV) placement, cardiac monitoring, and pulse oximetry. The cardiac monitor revealed a sinus rhythm and pulse oximetry revealed a blood oxygen level of 98%. The AC displayed signs of decerebrate posturing (abnormal body posture indicated by rigid extension of the arms and legs, downward pointing of the toes, and backward arching of the head). The instructor called 911 to summon an ambulance at 1017 hours. The ambulance responded and arrived at the training site at 1023 hours. The AC was placed onto a stretcher, moved to the ambulance, and transported to the hospital (1027 hours). An oral airway could not be inserted due to the AC's clenched teeth. As the ambulance neared the hospital, the AC's condition worsened; his blood pressure increased to 230/120 millimeters of mercury (mmHg), his pulse slowed to 56 beats per minute, and his breathing slowed to 12 breaths per minute. The ambulance arrived at the hospital's ED at 1034 hours.

Inside the emergency department, the AC was unresponsive and initially breathing on his own. His blood pressure rose to 229/137 mmHg, and his heart rate increased to 136 beats per minute. He stopped breathing and was intubated (breathing tube inserted into the trachea). Tube placement was confirmed by x-ray and an end tidal carbon dioxide test. An EKG revealed ST segment depressions in leads V2 – V6 and leads I and II. A computed tomography (CT) scan of the brain revealed a very large left hemispheric cerebral hemorrhage (bleed) with a midline shift. Chest x-rays revealed borderline cardiomegaly and pulmonary edema. Over six hours after arriving at the ED, the AC was pronounced brain dead at 1700 hours. Preparations then began for organ donations. Cardiac catheterization was performed on April 4th, which revealed a left ventricular ejection fraction of 70%-75% and no significant coronary artery stenosis.

Medical Findings. The death certificate (completed by the attending physician in the ED) listed "brain death due to brain aneurysm" as the cause of death. No autopsy was performed.

The AC was 68 inches tall and weighed 190 pounds, giving him a body mass index (BMI) of 28.8 kilograms per square meter (kg/m^2). A BMI of 25.0 to 29.9 kg/m^2 is considered overweight.[1]

The AC underwent numerous annual ERT physical evaluations beginning in 1986. His chest x-rays and EKGs were normal. The AC had a history of elevated cholesterol beginning in 1996 and was advised by the facility contract physician to undergo a Step 1 diet including limiting fat and cholesterol intake. At the time of his death, the AC was not taking any prescription medications. According to his wife and crew members, he expressed symptoms of occasional headaches which were attributed to allergies, job stress, and vision problems. He complained of a headache the day before he left for training.

DESCRIPTION OF THE FACILITY EMERGENCY RESPONSE TEAM

At the time of the NIOSH investigation, this ERT consisted of 56 volunteer facility members, served a facility workforce of 332 in a 250-acre area, and had one fire station. The ERT members were employed full-time by the facility as workers with various job duties, but volunteered on the ERT as extra duty.

Membership and Training. The ERT requires all applicants to:

- Complete an application
- Possess a valid state driver's license
- Complete the state minimum standards for the

selected position: Medical Team (emergency care attendant), Hazardous Materials Team, High Angle Rescue Team, or Fire Team
- Pass a physical ability test
- Pass an oral interview, a background investigation, and a pre-placement physical examination

The applicant is then offered membership on the ERT and is given a pager which is used to notify team members of an emergency. Members may elect to join multiple teams, but must obtain State certification before performing emergency response activities. Facility employees who are assigned to operations work 12-hour shifts from 0430 hours to 1630 hours.

The AC was certified as a Fire Fighter (interior and exterior), Professional Fire Fighter Qualifications Board, Emergency Care Attendant, Hazardous Materials Technician, Driver Operator, and confined space rescuer. He had over 20 years of firefighting experience on the ERT. He was not a member of any other FD.

Pre-placement and Annual Medical Evaluations. A pre-placement and annual medical evaluation is required for all ERT candidates and members, respectively. The components of these evaluations are:

- Complete medical history
- Physical examination
- Vital signs
- Blood tests: Complete blood count

  Complete metabolic panel (sequential multiple analysis [SMA] 22)
- Lipid panel
- Vision screening
- Audiogram
- Urinalysis
- Urine drug screen
- Pulmonary function (spirometry)
- Resting EKG
- Chest x-ray

The facility physician performs the medical evaluations and forwards the clearance-for-duty decision through the Human Resources office to the ERT Fire Chief, who makes the final clearance for duty determination. A return-to-duty medical clearance is required from the facility physician for duty-related injuries. If a non-duty-related illness prevents fire fighters from performing their duty, a return-to-duty clearance may be required by the fire fighter's primary care physician. The clearance is reviewed by the Human Resources office, which makes the final clearance decision. Respirator fit testing and medical clearance to wear a respirator occurs annually.

A physical agility test (hose carry, hose hoist, ladder climb, advance a charged hoseline, and victim carry) is required for ERT candidates, but not for members. Exercise equipment (strength and aerobic) is available at the facility, but participation is voluntary. Other than annual health fairs (blood pressure testing and prevention information), there is no wellness program.

DISCUSSION

Stroke and Cerebral Aneurysms. A stroke is defined as the sudden development of a focal neurological deficit.[2] Stroke (cerebrovascular disease) causes about 200,000 deaths each year in the United States, the incidence of which increases with age.[3] The American Heart Association identifies fifteen risk factors for stroke.[3] This includes three factors over which the individual has no control (increasing age [over age 55], male gender, and family history), and twelve which are modifiable (high blood pressure, cigarette smoking, diabetes mellitus, carotid artery disease, heart disease, transient ischemic attacks, high red blood cell counts, high cholesterol, physical inactivity and obesity, excessive alcohol consumption, use of some illegal drugs, and prior stroke or heart attack).

Strokes are broadly grouped into two types: ischemic (reduced blood flow due to an obstruction within a blood vessel) and hemorrhagic (a ruptured blood vessel).[4] Ischemic strokes are three times

more common than hemorrhagic strokes.[5] While the risk factors for both types are generally the same, they differ with regard to cholesterol. Recent studies have suggested that high cholesterol levels are associated with ischemic strokes, but are protective for hemorrhagic strokes.[6-10] The AC had one non-modifiable risk factor (male gender) and one modifiable risk factor (high cholesterol) for an intracerebral stroke.

While head trauma can cause intracranial hemorrhages, these are typically subdural or epidural, not intracerebral.[3] The AC's wife and crew members did not report any recent episodes of head trauma, nor was there any report of head trauma by the large number of physicians examining and evaluating him. Thus, the AC's stroke was not due to head trauma received during the fire suppression training.

The AC had a hemorrhagic stroke in the brain's left hemisphere, with a midline shift due to a ruptured cerebral aneurysm. Although cerebral aneurysms are relatively common (3%-5% of the U.S. population), most do not rupture.[11-13] When they do rupture, however, the mortality rate is high (40%-50%).[14]

Most people are unaware they have a cerebral aneurysm until it ruptures. Rupture is typically manifested as the sudden loss of consciousness that may be preceded by a brief moment of excruciating headache. In about 45% of cases, severe headache associated with exertion is the presenting complaint.[4] While headache can be an early symptom of a stroke, it is a common symptom and certainly not specific for a stroke. Without other symptoms of a stroke (sudden numbness or weakness of the face, arm or leg, especially on one side of the body; sudden confusion, trouble speaking or understanding; sudden trouble seeing in one or both eyes; or sudden trouble walking, dizziness, loss of balance or coordination), further evaluation at the scene or medical referral were not warranted. The AC had a moment of speech difficulty when the Fire Chief tried to talk to him. However, the AC soon became unconscious and did not communicate further.

Risk factors associated with hemorrhagic strokes due to a ruptured aneurysm are slightly different than the risk factors for all strokes mentioned earlier. For hemorrhagic stroke, these include:

- Size and location of the aneurysm[12,15,16]
- Cigarette smoking[15,17]
- Hypertension [15,17]
- Heavy use of alcohol[5]
- Family history of subarachnoid hemorrhage[18-20]
- Female gender[5]
- African-American race [5]
- Low level of leisure time physical activity[21,22]

The AC did not have any of the above risk factors. There are no practical screening tests for stroke, particularly intracerebral hemorrhagic strokes.

Physical Activity and Stroke. The association between lack of physical activity and ischemic heart disease is well established.[23,24] Given that most strokes are ischemic and that ischemic strokes and ischemic heart disease share a common pathophysiology, the association between the lack of physical activity and strokes is not surprising.[25,26] Recently, studies have also established a link between lack of physical activity and hemorrhagic strokes.[21,22]

The relationship between stroke and physical activity typically shows a "U"-shaped association (lack of physical activity or very heavy physical activity is associated with increased risk for a stroke, while moderate physical activity is protective).[22,25] One possible explanation for this finding is that heavy physical exertion may "trigger" a stroke, as with heart attacks (acute myocardial infarctions).[27-29] This seems plausible from a pathophysiological perspective because blood pressure rises during heavy physical exertion,[30] and elevated blood pressure could trigger the blood vessel to rupture.

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of

all civilian occupations.[31] Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. Even when energy costs are moderate (as measured by oxygen consumption) and work is performed in a thermoneutral environment, heart rates may be high (over 170 beats per minute), owing to the insulative properties of the personal protective clothing.[32] The AC performed fire suppression training while wearing full bunker gear and SCBA weighing about 50 pounds. This is considered a very heavy level of physical exertion.[31,33]

Given this information, NIOSH investigators conclude that this AC's stroke was due to a ruptured aneurysm, possibly triggered by the heavy physical exertion required to perform the fire suppression training while wearing full bunker gear and SCBA weighing about 50 pounds.

NIOSH investigators, however, cannot definitively determine whether the physical exertion played a role in his death.

RECOMMENDATIONS

The following recommendations would not have prevented this fire fighter's death. However, NIOSH investigators offer these recommendations to address general safety and health issues:

Recommendation #1: 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, *Standard on Fire Department Occupational Safety and Health Program*, requires FD members who engage in emergency operations to be evaluated annually, and to be certified by the FD as having met the physical performance requirements identified in paragraph 8-2.1.[34] Currently, the ERT only requires post-offer/pre-placement physical ability tests.

Recommendation #2: Discontinue routine annual electrocardiograms (EKG) unless medically indicated.

According to NFPA 1582, "periodic resting electrocardiograms have not been shown to be useful but can be reasonable as a member's age increases."[35] The EKG tracing during a stress test is a much better tool to identify heart abnormalities. Therefore, NIOSH recommends the Facility continue the resting EKG as part of its post offer/pre-placement medical evaluation, but discontinue the annual resting EKG performed as a screening test for all FF. These annual resting EKGs represent an unnecessary expense for the Facility. In addition, the resting EKG is not recommended by the OSHA Hazmat standard unless clinically indicated.[36,37]

Recommendation #3: Discontinue annual screening chest X-ray unless medically indicated.

According to NFPA 1582, "chest x-rays shall include an initial baseline and shall be repeated every 5 years or as medically indicated."[35] Chest X-rays are currently being conducted every year during the Facility's annual medical evaluation. These X-rays expose members to unnecessary radiation and represent an unnecessary expense for the Facility. In addition, these X-rays are not recommended by the OSHA Hazmat standard unless clinically indicated (e.g., respiratory symptoms).[36,37]

Recommendation #4: Phase in a wellness/fitness program for fire fighters to reduce risk factors for CVD and improve cardiovascular capacity.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[34] NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*, provides the minimum requirements for a health-related fitness program.[38]

In 1997, the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (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 FDs across the United States joined this effort to pool information about their physical fitness programs and create a practical fire service program.[39] Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.[40-42] Similar cost savings have been reported by the wellness program at the Phoenix FD, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.[43]

The National Volunteer Fire Council (NVFC)'s *Health and Wellness Guide* provides guidance to volunteer FDs on how to administer a wellness/fitness program and its components.[44] Given the nature of the ERT function at this facility, the NVFC program might be a more appropriate model than the IAFF/IAFC program.

Recommendation #5: Perform an autopsy on all on-duty fire fighter fatalities.

In 1995, the United States Fire Administration (USFA) published the *Firefighter Autopsy Protocol*.[45] 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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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, a Kentucky Certified Fire Fighter and Emergency Medical Technician (EMT) and a former Fire Chief, 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
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