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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 13, 2000*

Captain Dies as a Result of a Cardiac Arrest at the Scene of a Structure Fire - Alabama

SUMMARY

On July 4, 1999, a 52-year-old male volunteer Captain (the victim) responded to a structure fire. The victim, one of the first fire fighters to arrive at the fire scene, found a double-wide modular home fully involved in fire. The victim, wearing turnout pants and boots, acted as the Incident Commander and an Engine's Pump Operator. Heavy smoke clung to the ground as the victim helped fire fighters don and doff their self-contained breathing apparatus (SCBAs) during the incident. Soon thereafter, the victim commented to a nearby fire fighter that he needed help and collapsed.

Immediate assessment found the victim to be unresponsive, with no pulse or respirations. He was carried to an on-scene ambulance and cardiopulmonary resuscitation (CPR) (chest compressions with assisted ventilations via bag-valve-mask (BVM)) was initiated. Despite CPR and ALS administered by emergency medical technicians (EMTs), paramedics, and hospital emergency department (ED) personnel for 24 minutes, the victim died. The death certificate listed the immediate cause of death as a myocardial infarction (heart attack). An autopsy was not performed.

The following recommendations address preventive measures that have been recommended by other agencies to reduce, among other things, the risk of on-duty heart attacks and cardiac arrests among fire fighters. These recommendations have not been evaluated by NIOSH but represent research presented in the literature, regulations passed by enforcement agencies such as the Occupational Safety and Health Administration (OSHA), consensus votes of technical committees of the National Fire Protection Association (NFPA), or products of labor/management technical committees within the fire service. This preventive strategy consists of (1) minimizing physical stress on fire fighters, (2) screening to identify and subsequently rehabilitate high-risk individuals, and (3) encouraging increased individual physical capacity (fitness). Steps that could be taken to accomplish these ends include

- ***Fire fighters should have annual medical evaluations 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 to wear self-contained breathing apparatus (SCBA).***
- ***Perform an autopsy on all fire fighters who were fatally injured while on duty.***
- ***Reduce risk factors for cardiovascular disease and improve cardiovascular capacity***

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. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at:

http://www.cdc.gov/niosh/firehome.html

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by offering a wellness/fitness program for fire fighters.

- ***Although this issue is unrelated to this fatality, fire departments should purchase personal alert safety system (PASS) devices and ensure that fire fighters wear and use them when involved in fire fighting, rescue, and other hazardous duties.***

INTRODUCTION AND METHODS

On July 4, 1999, a 52-year-old male fire fighter collapsed at the scene of a structure fire. Despite CPR and ALS administered by the emergency medical technicians, paramedics, and hospital emergency department personnel, the victim died. On December 14, 1999, NIOSH contacted the affected Fire Department to initiate the investigation. On January 12, 2000, NIOSH investigators from the Fire Fighter Fatality Investigation Team, Cardiovascular Disease Component, traveled to Alabama to conduct an on-site investigation.

During the investigation NIOSH personnel met with or interviewed the

- Fire Chief
- Fire Department personnel involved in this incident
- Family members
- Emergency medical technicians/paramedics providing treatment
- The victim's personal physician
- State Department of Forensic Science personnel

During the site visit NIOSH personnel also reviewed the

- Fire Department incident report
- Fire Department policies and operating procedures
- Fire Department training records
- Fire Department annual report for 1999
- Fire Department administrative records
- Hospital emergency department records
- Past medical records of the deceased
- Death certificate
- National Climatic Data Center data for the incident date

INVESTIGATIVE RESULTS

<u>*Emergency Scene Response*</u>. On July 4, 1999, at 0254 hours, County Dispatch dispatched the involved Fire Department to a structure fire. The structure involved was a single-story, double-wide, wooden frame modular home measuring 24 feet by 70 feet, and was located 4 miles from the Fire Department. Engine 2 (two fire fighters), Brush Truck (one fire fighter), First Responder Truck (Captain [victim]), Emergency Medical Service-2 (EMS-2 [one EMT]), and two additional fire fighters in their privately owned vehicles responded at 0301 hours. The Fire Department has an automatic aid agreement with three neighboring volunteer fire departments to assist on structure fires; they responded with a total of one Engine, two Tankers, and one ALS ambulance. This additional aid increased staffing by 10 members, including two paramedics and one EMT.

It is the Fire Department's policy to dispatch an ambulance staffed by EMTs to all structure fires. These vehicles are equipped with semi-automated external defibrillators (SAEDs) and ALS equipment.

The involved Fire Department arrived on the scene at 0307 hours to find the structure fully involved. Heavy smoke clung to the ground. The temperature was 73$^{\epsilon}$ F and the relative humidity was 88 %. Two 1½-inch handlines were deployed from Engine 2 to begin an exterior attack. Automatic-aid departments began to arrive soon thereafter, and two 1½-inch handlines were deployed from the additional Engine for an exterior attack. The victim acted as

Incident Commander and as Pump Operator of Engine 2. The bulk of the fire was knocked down by approximately 0335 hours. After assessing the situation, the victim ordered an "entry" team of four fire fighters to enter the structure and complete final extinguishment. The victim assisted the team in donning their SCBAs. The entry team entered the structure, completed final extinguishment, and exited the structure. The victim then assisted the entry team in removing their SCBAs. Throughout the incident, the victim was conversant and did not display any signs or symptoms of discomfort. Paramedics on the scene treated one of the structure's occupants and one fire fighter for smoke inhalation.

At approximately 0356 hours, the victim asked a nearby fire fighter to help him and then collapsed. Nearby fire fighters immediately assessed the victim and found him to be unresponsive, pulseless, and without respirations. Four fire fighters carried the victim toward EMS-2, parked 75 yards away. Midway to the ambulance, the victim was set down and his turnout pants and boots were removed. Once inside the ambulance, the victim was reassessed and found to be unresponsive, pulseless, and not breathing. CPR was begun. A SAED connected to the victim revealed ventricular fibrillation (V. Fib). The SAED advised a shock (electrical cardioversion), which was successfully administered. The heart rhythm converted to asystole (no heart beat). EMS 2 departed the scene at 0359 hours en route to the hospital. En route, the victim was intubated, an IV line was placed, and medications were administered consistent with ALS protocols.

En route, a pulse was regained. The pulse, slow and lasting approximately 3 minutes, gradually diminished until it became absent upon ED arrival at 0412 hours. ED records indicate that the victim arrived in full cardiopulmonary arrest without neurologic responses. The victim had no spontaneous respirations, and initial electrocardiogram monitor rhythm was described as "irregular, slow, wide, and agonal" with progressive diminution despite continued CPR and ALS. Eventually and irrevocably, the only monitored cardiac activity was artifacts of CPR. Resuscitative efforts in the ED were continued for 12 minutes until 0424 hours, when the victim was pronounced dead.

Medical Findings. The death certificate was completed by the ED physician on July 4, 1999. The immediate cause of death was listed as myocardial infarction (heart attack). No blood was sent for laboratory analysis during resuscitative efforts. According to post-mortem toxicology forensic specimen analysis, the victim's carboxyhemoglobin level was "negative." An autopsy was not performed.

The victim had numerous risk factors for coronary artery disease (CAD), including family history of CAD, male gender, age greater than 45 years, high blood pressure (hypertension), high blood cholesterol (hypercholesterolemia), and a lack of conditioned physical activity. He had been on blood pressure medication for 16 years and diagnosed with borderline high cholesterol in 1989. In 1998, he was prescribed medication for hypercholesterolemia. He closely monitored his blood pressure and cholesterol levels with the help of his family physician, medications, and controlled dietary intake, but these measurements remained elevated. In 1987, available medical records note that he underwent a graded exercise stress test (EST). This was a baseline screening ordered by his personal physician at the time because of his risk factors for CAD. The results of this EST were reported only as "Good - normal heart."

A little over a month before the victim's death, he was taken from work to an ED for evaluation of chest pressure and tightness. This chest tightness increased with exertion and anxiety. An electrocardiogram (EKG) performed in the ED

showed a normal heart rhythm, and blood tests (cardiac isoenzymes) were negative. He was admitted to the hospital and underwent a gated nuclear exercise stress test (EST) with no EKG changes, no chest pain, and a normal heart rhythm throughout the EST. Results were said to be within normal limits with no evidence of ischemia (inadequate blood circulation).

His blood pressure remained higher than normal limits throughout this hospitalization, and additional hypertensive medications were added. Additionally, he was found to have loud bruits (abnormal sounds produced by blood flow) in his carotid arteries (the blood vessels from the heart to the brain). Diagnostic ultrasound studies revealed significant stenosis (clogging) in both carotid arteries—75% stenosis in the left side and 40% in the right. The victim was referred to another hospital where surgery could be performed to treat this condition.

A surgical procedure was successfully performed on the left carotid artery. He was followed post-operatively by his surgeon and his family physician. Two weeks post-op, he told his physicians that he felt well and was not having any symptoms such as loss of consciousness, irregular heart beats, or chest pain. His blood pressure was better controlled with the additional medication.

After 3 weeks he was released to his regular job as a diesel mechanic, but he was advised to work outside in his yard for the next several days to become acclimated to the heat. He also owned a farm and raised cows. He described the demanding physical exertional nature of these two jobs to his physicians, but did not, according to his family physician, notify them that he was also a volunteer fire fighter. This fatal incident was the first time he had participated in a fire emergency since his surgery.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department was comprised of eight volunteers in one station serving a population of approximately 1,000 in a geographic area of 25 square miles. In 1999, the Department responded to 157 calls: 82 medical calls, 32 motor-vehicle accidents (MVA), 26 mutual-aid calls (includes medical, motor-vehicle accidents, and fires), six vehicle fires, six wildland fires, four structure fires, and one missing-child call.

Training. The victim had received fire fighter, CPR, and first-aid training, and had 10 years of fire-fighting experience. The state recognizes Insurance Services Office (ISO) minimum requirements for fire-fighter certification, which includes 160 hours of training. Thirty hours of State Fire College training are required for annual recertification. The State requires that a fire department maintain five certified fire fighters. Individual fire departments are responsible for setting up their own specific training requirements.

Medical Clearance and Physical Fitness. The Department does not require a medical evaluation prior to performing fire-fighting duties, does not require a periodic medical evaluation, does not require medical clearance for respirator usage, and does not require physical agility/fitness testing for new or current fire fighters.

DISCUSSION

Approximately 2 minutes after the victim's collapse, the SAED rhythm strip documented V. Fib. V. Fib is the most common type of arrhythmia associated with cardiac arrest, occurring in 65-80% of all cardiac arrests.[1] In the United States, atherosclerotic coronary artery disease (CAD) is the most common risk factor for cardiac arrest and sudden cardiac death.[1] Risk factors for its development include increasing age, male gender, family history of CAD,

smoking, high blood pressure, high blood cholesterol, obesity, physical inactivity, and diabetes.[2] The victim had many of these risk factors.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.[3] However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.[4] 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.[5] This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. An autopsy was not performed, so the extent of the victim's CAD was unknown. However, atherosclerotic plaque formation and hypertension are systemic diseases that affect arteries throughout the body.[6] His family physician stated that with his severe atherosclerotic carotid artery disease, it could be estimated that the victim had 30 to 40% CAD.

Blood clots, or thrombus formation, in coronary arteries is initiated by disruption of atherosclerotic plaques. 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 occur during heavy exercise.[6,7] Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[8-12]

Fire-fighting 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.[13-15] The mental and physical stress of responding to the emergency, operating the pump controls, acting as Incident Commander, and his probable underlying atherosclerotic CAD, all contributed to this fire fighter's "probable" heart attack, subsequent cardiac arrest, and sudden death. The term "probable" is used because an autopsy and/or blood tests (cardiac isoenzymes) are required to "confirm" a heart attack (myocardial infarction) and neither of these were performed. If there is a heartbeat, an EKG can also confirm a heart attack.

RECOMMENDATIONS AND DISCUSSION

The following recommendations address health and safety generally. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These recommendations have not been evaluated by NIOSH but represent research presented in the literature or of consensus votes of Technical Committees of the National Fire Protection Association or labor/management groups within the fire service. In addition, they are presented in a logical, programmatic order and are not necessarily listed in order of priority. This preventive strategy consists of (1) minimizing physical stress on fire fighters, (2) screening to identify and subsequently rehabilitate high-risk individuals, and (3) encouraging increased individual physical capacity (fitness). Steps that could be taken to accomplish these include

Recommendation #1: Fire fighters should have annual medical evaluations 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 periodic medical evaluations for fire fighters can be found in NFPA 1582, Standard on Medical

Requirements for Fire Fighters, [16] and in the report of the International Association of Fire Fighters/ International Association of Fire Chiefs wellness/ fitness initiative.[17] If these medical evaluations diagnose a previously unidentified medical condition, the condition should be checked against the medical conditions that **should** (Category A) or **could** preclude (Category B) individuals from performing fire-fighter activities.[16] This standard (NFPA 1582) should be shared with physicians responsible for clearing individuals for fire-fighting duties.

Recommendation #2: Provide fire fighters with medical evaluations to determine their fitness to wear self-contained breathing apparatus (SCBA).

In 1997, OSHA published its revised respiratory protection standard.[18] This standard, among other things, requires that a medical evaluation of fire fighters wearing SCBA be performed by a physician or other licensed health-care professional. This evaluation could consist of a screening questionnaire (enclosed) to ascertain if additional medical evaluations or a medical examination is warranted. Because Alabama does not have an Occupational Safety and Health Administration (OSHA)-approved state plan, its state and municipal employees, such as fire fighters, are not covered under the Occupational Safety and Health Act. Therefore, State, County, or City fire departments in Alabama are NOT required to comply with OSHA standards. Nonetheless, we recommend voluntary compliance with this aspect of the respiratory protection standard to ensure that fire fighters can safely wear SCBA.

Recommendation #3: Perform an autopsy on all fire fighters who were fatally injured while on duty.

In 1995, the United States Fire Administration (USFA) published the "Firefighter Autopsy Protocol."[19] This publication 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."

The State Fire Marshal advised the family not to conduct an autopsy.

Recommendation #4: Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by offering a wellness/ fitness program for fire fighters.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[20] In 1997, the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) joined in 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 with a video detailing elements of such a program.[17] Fire departments should review these materials

to identify applicable elements for their department.

Recommendation #5: Although this issue is unrelated to this fatality, fire departments should purchase personal alert safety system (PASS) devices and ensure that fire fighters wear and use them when involved in fire fighting, rescue, and other hazardous duties.

The PASS is a small electronic device worn by the fire fighter which will emit a distinctive audible alarm if the fire fighter becomes motionless for 30 seconds, or it can be activated manually if needed. This device is designed to assist rescuers in locating the fire fighter. All fire fighters who enter hazardous areas should be provided with and use a PASS device.[20]

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INVESTIGATOR INFORMATION

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