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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 23, 1998

Fire Fighter Dies as a Result of a Cardiac Arrest While Working at the Scene of a Motor Vehicle Crash - Alabama

SUMMARY

On June 27, 1998, a 43-year-old male Captain lost consciousness enroute to the hospital after serving as Incident Commander at the scene of a motor vehicle crash. The Captain was assisting injured civilians and assisting with clean-up operations when he complained of heartburn and stomach pain. Witnesses noted his excessive sweating during these activities and attributed this to the high temperature and high humidity. Approximately 50 minutes into the response, the victim began completing response paperwork inside the Engine's air conditioned cab. While sitting in the officer's seat (passenger side), he activated the Engine's manual siren to signal for help. As two fire fighters approached the Engine, he said "I need to go to the doctor," without mentioning any particular symptoms. Approximately 1 minute into the 4 minute ride to the hospital, he lost consciousness, but maintained a pulse and respirations. Approximately 45 seconds from the hospital, he went into full cardiac arrest.

Upon arrival at the emergency room, cardio-pulmonary resuscitation (CPR), followed by advanced life support (ALS), was performed in the hospital emergency department. After approximately 45 minutes, resuscitation measures were discontinued. The death certificate listed cardiopulmonary arrest as the immediate cause of death, as a consequence of acute coronary insufficiency due to myocardial infarction. The autopsy report listed the final diagnosis as acute myocardial infarction secondary to thrombosis of severely compromised coronary arteries.

The following recommendations address health and safety issues in general. These recommendations rely on a three-pronged strategy for reducing the risk of on-duty heart attacks and cardiac arrests among fire fighters, as

proposed by other agencies. This 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. Steps that could be taken to accomplish these include:

- ***Provide adequate fire fighter staffing to ensure safe operating conditions***
- ***Provide fire fighter medical evaluations that are consistent with the content and frequency as those required by OSHA and recommended by NFPA, and the International Association of Fire Fighters/International Association of Fire Chiefs***
- ***Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by phasing in a mandatory wellness/fitness program for fire fighters.***

INTRODUCTION & METHODS

On June 27, 1997, a 43-year-old male Captain lost consciousness enroute to the hospital after serving as Incident Commander at the scene of a motor vehicle crash. Despite CPR and ALS administered by the emergency room personnel, the victim died. NIOSH was notified of this fatality on June 30, 1998, by the United States Fire Administration. On September 21, 1998, Tommy Baldwin, a Safety and Occupational Health Specialist, Thomas Hales, Senior Medical Officer, and Sally Brown, Epidemic Intelligence Service Officer from the NIOSH Fire Fighter Fatality Investigation and Prevention Program, traveled to Alabama to conduct an onsite investigation of the incident.

During the investigation NIOSH personnel met with and interviewed the

- Fire Chief
- Local President of the International Association of Fire Fighters (IAFF)
- The City’s Loss Prevention Director
- Fire Department personnel involved in this incident
- Mayor

- Family members
- Training Officer.

During the site visit NIOSH personnel also reviewed:

- Existing Fire Department investigative records, including incident reports, co-worker statements, dispatch records, police investigation report, the victim's medical evaluations conducted for the Fire Department, and photographs of the crash scene
- Fire Department policies and operating procedures
- Fire Department training records
- Fire Department annual report for 1997
- Past medical records of the deceased
- The emergency department's records of the resuscitation effort
- Autopsy results and death certificate of the deceased.

NIOSH personnel also

- Contacted the medical group conducting the Fire Department's medical evaluations
- Contacted the pathologist who performed the autopsy.

INVESTIGATIVE RESULTS

Crash Scene Response. On June 27, 1998, at 0716 hours, Central Dispatch notified the Fire Department of a motor vehicle crash with two people ejected and a fuel spill. Engine 515, staffed by three department personnel (Captain [the victim], engineer [driver/operator], and fire fighter), responded at 0717 hours. The crew, which had been on duty just 16 minutes prior to the dispatcher's call, arrived at the crash scene at approximately 0720 hours.

At the scene, two persons had been injured in a three-vehicle crash. Injuries sustained to the civilians were not critical, but they required ambulance transport to the local hospital's emergency department. The Captain and fire fighter assisted the crash victims, while the Engineer began clean-up operations. At 0727 hours, the Captain, serving as Incident Commander, requested an additional Engine to bring "oil dry" to the scene to absorb the diesel fuel leaking from the disabled vehicles. At 0729 hours, Engine 510 (Captain, Engineer, and fire fighter) responded with the "oil

dry" to the crash scene. Engine 510 arrived on scene at 0735 hours. The victim and other crew members lifted the 40- to 50- pound bags of "oil dry" off the Engine and spread it onto the roadway. Shortly thereafter, additional crew members began sweeping the "oil dry" off the road. At that time the victim related to the fire fighter from Engine 515 that he had heartburn and needed a "Rolaid." The victim was sweating excessively, although no one considered this noteworthy, considering the weather conditions (approx 85° F with high humidity).

At 0742 hours, Engine 510 departed the scene for Station 2 to retrieve more "oil dry." The victim spoke to the Engineer of Engine 515 about the incident. The Engineer, noting the victim's excessive sweating, suggested that he complete the incident report inside the air-conditioned cab of Engine 515. The victim entered the cab of Engine 515, occupying the officer's (front passenger) seat, to complete the report. At approximately 0818 hours, the victim activated the Engine's manual siren. Two fire fighters went to the Engine to determine if another emergency response call had been received. The victim leaned out the window and said, "I need to go to the doctor." A fire fighter asked him what was wrong, and he repeated, "I need to go to the doctor."

The crew (Engineer and fire fighter) immediately loaded their shovels into Engine 515, and at 0820 hours, were enroute to the hospital. The victim lost consciousness about 1 minute into the 4-minute ride to the hospital. At 0821 hours, Engine 515 notified Central Dispatch to alert the hospital that they were responding with a possible heart attack victim. The fire fighter, riding in the enclosed crew compartment behind the officer's seat, reached forward, slapped the victim on the arm and shouted his name. The victim regained consciousness with a weak carotid pulse and shallow respirations.

At 0822 hours, Engine 515 notified Central Dispatch of their estimated arrival time at the hospital in 2 minutes. At this time the victim lost consciousness a second time. Again, the fire fighter struck the victim in the arm/chest area and again the victim responded by regaining consciousness with a weak carotid pulse and slow respirations. At 0823 hours, the victim lost consciousness a third time. The fire fighter tried to arouse the victim, with no success. At this time the Engine was approximately 45 seconds from the hospital.

Engine 515 arrived at the hospital at 0824 hours. The victim was placed onto a hospital cot, where initial evaluation revealed the victim to be unconscious, pulseless, and without respiration. CPR was initiated, and he was wheeled into the emergency department where an intravenous line, an endotracheal tube, and heart monitor leads were placed. Initially, he had pulseless, slow (approximately 60 beats/minute) ventricular activity which degenerated into ventricular fibrillation. ALS administered by the hospital's emergency department for over 25 minutes was

unable to generate a pulse or spontaneous respirations. He was pronounced dead at 0850 hours.

Medical Findings. The death certificate was completed by the emergency department's physician. The immediate cause of death was listed as "cardiopulmonary arrest" due to "acute coronary insufficiency" due to "myocardial infarction" due to "exertional activity to be confirmed by post mortem." Blood tests in the emergency department revealed a carboxyhemoglobin level of 2.0%, indicating that the deceased was not exposed to excessive concentrations of carbon monoxide prior to his death. Blood alcohol and drug screens were negative.

Medical records indicated that the victim had several risk factors for coronary artery disease. He had two episodes of chest pain thought to be potentially related to coronary artery disease, the most recent episode being 2 years prior to his death. During that most recent episode, he was hospitalized, but blood tests for cardiac enzymes "ruled out" a heart attack (myocardial infarction). Three weeks later he underwent a graded exercise stress test (thallium and electrocardiogram [EKG]). His exercise test only lasted 7 minutes due to fatigue and leg pains. During those 7 minutes, no ischemic changes or arrhythmias were noted on his EKG. The thallium scan showed an anterior and inferior wall defect possibly "on the basis of diaphragm and soft tissue overlay attenuation." He maintained a moderate amount of work activity without chest pain, both on the job and off-the-job, right up to this event. He frequently experienced "heartburn," described as a burning epigastric pain occurring after meals and relieved by antacids. Pertinent findings from the autopsy, performed by a private pathologist at the family's request on June 27, 1998 are listed below:

- Acute myocardial infarction (2.2 cm) of the left lateral ventricle;
- Left atrial rupture (2.5 cm) with hemorrhage into the pericardial fat, but no hemopericardium present;
- Severe calcific coronary artery disease with circumflex artery thrombosis;
- Remote, global subendocardial myocardial infarct of the left ventricle;
- Moderate to severe chronic ischemic heart disease;
- Moderate biventricular hypertrophy;
- No evidence of significant valvular problems.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department was comprised of 33 uniformed personnel and served a population of 18,000 in a geographic area of 16.4 square miles. There were two fire stations where fire fighters worked 24 hours on duty (0700 hours to 0700 hours) and were off 48 hours. Each shift of an engine company was staffed with five fire fighters; however, due to vacation and/or sick days, the engine company was frequently staffed with less than four fire fighters.

In 1997, the department responded to 582 calls: 167 motor vehicle accidents, 76 false runs, 59 fire alarm systems responses, 42 spills; 42 canceled runs, 36 structure fires, 35 vehicle fires, 30 outdoor fires, 23 smoke calls, 16 electrical calls, 16 agency assistance, 12 ruptures/explosions; 10 good intent, 7 controlled burns, 6 EMS, 3 bomb threats, and 2 search and rescues.

Training. The Fire Department provides all new fire fighters with the basic 320-hour recruit training required by the State of Alabama. The department also recommends 20 hours of additional on-the-job training each month. The training is provided primarily during in-service days by the company officers of each engine company. The victim had 22 years of fire fighting experience, was a certified Fire Fighter Level II, and was promoted to Captain in March 1998.

Medical Clearance and Physical Fitness. All fire fighters in this department receive a pre-employment evaluation. The evaluation consists of a medical history, height, weight, blood pressure, visual acuity, audiometry, physical examination, spirometry, blood and urine tests, chest X-ray, and EKG. Other tests can be ordered at the discretion of the examining physician. Fire fighters with HazMat training (about half of the department) received annual evaluations consisting of medical history update, job exposure history, height, weight, visual acuity, and blood pressure. Other tests can be ordered at the discretion of the examining physician. In 1997, the department required this annual evaluation for all fire fighters in the department. The department does not have a specific medical clearance evaluation for respirator use. The victim had passed his annual medical evaluation approximately 9 months prior to his cardiac arrest. This department does not have a physical agility/fitness requirement for new or current fire fighters. In 1995, the department began a fitness training program to enhance the physical condition of fire fighters. The program has been administered by a local physical fitness coordinator. Fire fighters are required to spend at least 1 hour per shift at the gymnasium, but participation is not enforced.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) 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 coronary artery

disease, smoking, high blood pressure, high blood cholesterol, obesity, physical inactivity, and diabetes.[2] The victim had many of these risk factors, and, on autopsy, had severe atherosclerotic coronary artery disease in the three main coronary arteries.

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. On autopsy, the victim was found to have a blood clot (thrombosis) superimposed on an atherosclerotic plaque, completing blocking one of his coronary arteries (the circumflex artery). This blockage was responsible for his fatal heart attack (2.2-cm by 2.1-cm infarct in the left ventricle).

Blood clots, or thrombus formation, in coronary arteries are 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 proceeds and triggers the onset of acute heart attacks.[8-11]

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 response to the initial alarm and persist through the course of fire suppression activities.[12-14] The mental and physical stress of responding to the Fire Department alarm, assisting the injured civilians and assisting with clean-up activities in hot and humid weather, and the victims' underlying coronary artery disease all probably contributed to his heart attack, cardiac arrest, and sudden cardiac death. The autopsy also documented evidence of another heart attack that occurred at least 1 year prior to his death (1-cm subendocardial lesion in the left ventricle). According to our interviews and review of his medical records, the patient only complained of two episodes of chest pain. The first episode was noted in his chart 7 years ago, but no medical work-up was undertaken at that time. The most recent episode of chest pain occurred 2 years ago and he was admitted to the hospital for a "rule-out MI." During that hospitalization he was found, by EKG and blood tests (cardiac isoenzymes), NOT to have had a heart attack. As mentioned earlier in this report, 3 weeks after hospital discharge the victim did have a graded exercise stress test (thallium and EKG). The thallium scan showed an anterior and inferior wall defect thought to be "diaphragm and soft tissue overlay attenuation." This

defect, however, may well have represented this man's previous heart attack. On the other hand, up to 40% of all heart attacks are previously unrecognized for reasons that are unknown.[15]

This remote heart attack was not identified by several resting EKGs conducted over the past 7 years. This is not surprising given the location (subendocardial) and small size (1 cm) of his prior heart attack. In either case, why this victim did not have frequent episodes of angina (heart pain) during the moderate amount of physical activity he performed around the house is puzzling. During the NIOSH investigation, the possibility of toxic fumes from the "oil dry" used to clean up the leaking diesel fuel was mentioned as a possible contributing factor to the heart attack. Material safety data sheets of "oil dry" reveal that it is a 100% silica-based product. Silica is not known to cause acute or chronic cardiac problems; therefore, it is extremely unlikely that "oil dry" could have produced cardiac toxicity precipitating this man's sudden cardiac death. Another possibility is that this man's chronic "heartburn" was actually heart pain (angina). While plausible, we consider this unlikely given the discomfort's onset, type, location, and relief via antacids. It is more likely that he suffered a "silent" or "painless" heart attack several years ago. Silent MIs (painless heart attacks) are not unusual events, representing up to 20% of all heart attacks.[15]

One final issue raised several times during the investigation was the rescuing fire fighters' decision to take the victim directly to the hospital, rather than requesting an ambulance. Given that the victim was initially conscious and that the hospital was only 4 minutes away, we believe this was a logical choice. Once the victim lost consciousness, 45 seconds from the hospital, a correct decision was made to continue onto the hospital rather than stopping the Engine to transfer the victim to the bed of the Engine and perform CPR while waiting for an ambulance to arrive.

RECOMMENDATIONS and DISCUSSION

The following recommendations address general health and safety measures. 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 (NFPA)or labor/management groups within the fire service. In addition, they are presented in a logical programmatic order, and are not listed in a priority manner.

Recommendation #1: Provide adequate fire fighter staffing to ensure safe operating conditions.

Discussion: On the day of the incident, there were 3 crew members offduty (sick leave or vacation), leaving each Engine company with 3 "on-duty" personnel. Interviews conducted during this investigation suggested this is a common occurrence. OSHA's revised respiratory protection standard requires employees working in "Atmospheres that are Immediately Dangerous to Life or Health," which includes structural firefighting, to work in a double buddy system.[16] This double buddy system, or "2-in/2-out" rule, is designed to protect fire fighters while conducting interior structural fire fighting operations. Because municipal Fire Departments are public agencies with public employees, and because Alabama does not operate an OSHA-approved State plan, the employer is NOT REQUIRED to comply with this or other OSHA standards. Nonetheless, we recommend voluntary compliance with this OSHA standard to ensure fire fighter safety. This could be accomplished by any of the following: (1) increasing the number of fire fighters assigned to a company, (2) hiring fire fighters to act as "floaters" to fill in positions vacated by employees who are sick or who are on vacation, (3) staggering vacation days in conjunction with hiring floating fire fighters. The basis for this standard is improvement of worker safety while fighting interior structural fires.

Recommendation #2: Provide fire fighter medical evaluations that are consistent with the content and frequency as those required by OSHA and recommended by NFPA, and the International Association of Fire Fighters/International Association of Fire Chiefs.

Discussion: Guidance regarding the content and scheduling of periodic medical examinations for fire fighters can be found in the OSHA Repiratory Protection Standard,[16] NFPA 1582, Standard on Medical Requirements for Fire Fighters,[17] and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs wellness/fitness initiative.[18] As discussed previously, the department is not legally required to follow these standards. The department has contracted with a single medical group to provide fire fighter medical evaluations. This medical group has tried to follow NFPA 1582 Standard, but varying levels of funding for the department's medical evaluations have hampered compliance. For example, 1997-1998 was the first year that all fire fighters received an annual evaluation. In addition, NFPA 1582 suggests exercise stress tests for those with at least one coronary artery disease (CAD) risk factor beginning at age 35. This department has not conducted any exercise stress tests.

In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire fighting tasks. Applying NFPA 1582 involves legal and economic issues, so it should be carried out in a nondiscriminatory manner. Appendix D of NFPA 1582 provides guidance for Fire Department Administrators regarding legal considerations in applying the standard. Economic issues go beyond the costs of

administering the medical program. Department administrators, unions, and fire fighters must also deal with the personal and economic costs of the medical testing results. NFPA 1500 addresses these issues in Chapter 8-7.1 and 8-7.2.[19] The success of medical programs may hinge on protecting the affected fire fighter. The department should provide alternate duty positions, if possible, for fire fighters in rehabilitation programs. If the fire fighter is not medically qualified to return to duty after repeat testing, supportive and/or compensated alternatives for the fire fighter should be pursued by the Department.

Recommendation #3: Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by phasing in a mandatory wellness/fitness program for fire fighters.

Discussion: NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[19] In 1997, the International Association of Fire Fighters and the International Association of Fire Chiefs 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.[18] Fire departments should review these materials to identify applicable elements for their department.

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