



Lieutenant Dies While Directing Interior Ventilation and Primary Search Operations at a Fire in a Three-Story Dwelling—Pennsylvania

SUMMARY

On January 27, 1998, a 47-year-old male Lieutenant responded to a fire in a three-story dwelling. While laddering the building and directing interior ventilation and primary search operations, the victim had an unwitnessed collapse. He was found by a firefighter returning for further instructions. After approximately 55 to 60 minutes of CPR and advanced life support (ALS) on scene and at the hospital, a normal heart rhythm was regained. Neurologic consultation was requested and tests indicated that the victim's unwitnessed collapse resulted in anoxic encephalopathy (brain death), so he was taken off life support and died on February 3, 1998. The death certificate and the autopsy, completed by the City Medical Examiner, listed "acute myocardial infarction" due to "atherosclerotic cardiovascular disease" as the immediate cause of death and "smoke and soot inhalation" as significant conditions.

Other agencies have proposed a three-pronged strategy for reducing the risk of on-duty heart attacks and cardiac arrests among fire fighters. 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. The following issues are relevant to this fire department:

- ***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.***
- ***Reduce risk factors for cardiovascular disease and improve cardiovascular capacity***

by phasing in a mandatory wellness/fitness program for fire fighters.

- ***All personnel entering a potentially hazardous atmosphere should wear an SCBA.***

INTRODUCTION & METHODS

On January 27, 1998, a 47-year-old male Lieutenant lost consciousness while directing interior ventilation and search activities at a fire in a three-story dwelling. Despite CPR and ALS administered by crew members, fire department paramedics, and emergency department personnel, and emergency cardiac catheterization, the victim died. NIOSH was notified of this fatality on February 3, 1998, by the United States Fire Administration. On June 8, 1999, NIOSH contacted the affected Fire Department to initiate the investigation. On July 12, 1999, a Safety and Occupational Health Specialist, an Epidemiologist, and a Nurse Epidemiologist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Pennsylvania to conduct an on-site investigation of the incident.

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:

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During the investigation NIOSH personnel met with the following:

- Commissioner of the Fire Department (FD)
- Deputy Fire Commissioner for Technical Services
- Fire Marshal
- Fire Department Personnel Director
- Local President of the International Association of Fire Fighters (IAFF)
- Crew members involved in this incident
- Fire Department paramedic involved in this incident
- Victim's spouse
- Spouse's legal counsel
- Victim's personal physician
- Emergency Room (ER) personnel who treated the victim

During the site visit NIOSH personnel reviewed

- Existing FD investigative records, including the fire fighter fatality investigation report, incident reports, coworker statements, and dispatch records
- The victim's personnel record maintained at the FD
- Emergency medical services—ambulance report
- The hospital's records of the resuscitation effort
- Autopsy results and death certificate
- Past medical records of the deceased
- FD policies and operating procedures
- FD training records
- The FD annual report for 1998

NIOSH personnel also visited the area where the structure fire occurred.

INVESTIGATIVE RESULTS

Incident Response. On January 27, 1998, at approximately 1444 hours, a citizen stopped at the quarters of Engine 27 (which also housed Battalion

3 and Medic 13) and notified them of a structure fire approximately one block away. A paramedic took the information, informed the companies in the station, and then informed Dispatch. At 1446 hours, Engine 27, Engine 13, Ladder 1, Ladder 14, Battalion 3, and Medic 13 were dispatched on a tactical box alarm to a three-story dwelling with smoke showing from the second floor. Battalion 3 (Battalion Chief and an Aide), Engine 27 (Lieutenant and three Fire Fighters), and Medic 13 (two Paramedics) responded immediately. Battalion 3 went to the structure to perform size-up. Medic 13 (squad) pulled out onto the street to stand by. The portable radio, stretcher, backboard, trauma bag, and monitor were removed from the squad and placed near the fire building in case of need. Ladder 1 (Lieutenant [victim] and four Fire Fighters), Ladder 14 (Captain and four Fire Fighters), and Engine 13 (Acting Lieutenant and three Fire Fighters) responded to the dispatch. Engine 27 arrived on scene at 1447 hours, pulled in front of the fire building, and connected to a hydrant.

At 1449 hours, Battalion 3 radioed Dispatch that all occupants were out of the structure and there was heavy fire on the second floor in the front and heavy smoke on the third floor in the front. All companies were placed in service and told to lead off with 1¾-inch hoselines. The building's occupant blocked the fire fighters from entering the building and a police officer had to be summoned, thus delaying immediate entry. Engine 27 crew members, wearing full bunker gear and SCBA, then stretched a 1¾-inch hoseline to the second floor via the interior stairway. Responding companies encountered heavy smoke on the second and third floors in the front.

Crew members checked the middle bedroom for fire extension but found none. They located the fire in the front bedroom and began to extinguish it. Ladder 1 arrived on scene at 1449 hours but had to park approximately 165 feet away because a parked



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car was partially blocking the street. Three fire fighters from Ladder 1 removed a 35-foot portable ladder and proceeded to the front of the structure. The victim, wearing full bunker gear without SCBA, removed a 16-foot portable ladder and proceeded to the rear of the structure (about 195 feet away). Ladder 14 and Engine 13 arrived at 1450 hours. The victim was assisted in setting up the ladder by an off-duty Lieutenant who had been visiting the Engine 27 fire station. At approximately 1451 hours, the victim climbed the ladder and broke out the middle bedroom rear window and part of the bathroom window to aid in ventilation of the second floor. He entered the second floor middle bedroom to direct interior ventilation operations. Two fire fighters from Ladder 14 ascended the portable ladder behind the victim and entered the structure. Smoke condition in the bedroom was medium. The Ladder 14 fire fighters removed a door between the front bedroom and the middle bedroom. The victim, kneeling a few feet from the window, told these two fire fighters to finish taking out the second floor bathroom window to further ventilate the second floor and to check the third floor. Both proceeded to conduct a search of the dwelling and assisted in opening walls and ceilings on the third floor.

The Engine 27 crew extinguished the fire in the second floor front bedroom. At 1454 hours, Battalion 3 declared the fire under control. After approximately 5 minutes, a fire fighter from Ladder 14 returned to the second floor middle bedroom and found the victim face down, unconscious, and cyanotic in the same location where the victim had previously been kneeling. The fire fighter gave the victim mouth-to-mouth respirations and called for assistance. Returning from the third floor, the other fire fighter from Ladder 14 began to clear a way down the stairs and a fire fighter from Ladder 1 helped carry the victim out of the building via the interior stairway.

Fire fighters brought the victim outside. A paramedic removed the equipment from the stretcher, while the other paramedic ran up the street to the squad to prepare it for transport. Fire fighters placed the victim onto the backboard atop the stretcher and removed his turnout coat. The victim was cyanotic, unresponsive, not breathing, and pulseless. Fire fighters began cardiopulmonary resuscitation (CPR) (chest compressions and mouth-to-mouth) and wheeled the stretcher up the street and into Medic 13. Once inside the squad, the remainder of the victim's gear was removed, he was intubated, and CPR (chest compressions and assisted ventilation with a bag-valve-mask and 100% oxygen) continued. At 1459 hours, Battalion 3's Aide tried to notify Dispatch that a fire fighter was down but encountered radio problems. At 1501 hours, Medic 13 notified Dispatch that they were en route to the hospital with a "Code Blue" (someone requiring CPR). Intravenous (IV) access was established, and intravenous normal saline solution was administered. Two attempts were made to attach monitor electrodes to the victim but were unsuccessful due to his chest hair and perspiration. Medic 13 arrived at the hospital at 1510 hours. CPR and ALS procedures were performed for a total of 6 minutes on scene and for 9 minutes during transport to the hospital.

Upon arrival in the hospital emergency department (ED), the victim was found to be in asystole (no heart beat), unresponsive, and without vital signs. ALS activities (including the administration of a cyanide toxicity antidote because of the description of the fire scene and the victim's smoke inhalation) were restarted. Three defibrillation shocks in increasing voltage were administered before cardiac activity occurred. After approximately 45 to 50 minutes of aggressive ALS, a normal heart rhythm was regained. The electrocardiogram showed changes to the heart consistent with an acute anterior wall myocardial



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infarction (heart attack). The victim did not regain consciousness.

The victim was taken for emergency cardiac catheterization, which revealed a ruptured plaque with thrombus of the mid-left anterior descending coronary artery; the distal end of this artery was large and free of disease. There was difficulty positioning the guidewire used in angioplasty in this vessel due to this occlusion. After cardiac catheterization, the victim was taken to a cardiac intensive care unit, on a respirator but with a stable heart rhythm. Neurologic consultation was requested and tests including computerized tomography (CT) and electroencephalograms (EEGs) indicated that the victim's unwitnessed collapse, during which he may have been apneic (without oxygen) for as long as 5 to 6 minutes, resulted in anoxic encephalopathy (brain death). It was believed that a prognosis for a "meaningful recovery" for this individual was "0 - 5%." On January 30th, the victim's family requested that he be taken off life support because of his poor prognosis and decline in health status, including seizure activity and cardiac arrhythmias. On February 3, 1998, at 0614 hours, the victim died.

Medical Findings. The death certificate was completed by the City Medical Examiner, who listed "acute myocardial infarction" due to "atherosclerotic cardiovascular disease" as the immediate cause of death and "smoke and soot inhalation" as other significant conditions. The victim had five risk factors for coronary artery disease (male gender, advancing age, hypertension, high cholesterol, and history of smoking). Medical records indicated that the victim had a medical history of hypertension, diagnosed by his personal physician in mid-1995, which was controlled by medication. He was diagnosed in mid-1996 as having "borderline" hypercholesterolemia (but with a normal HDL cholesterol level). He was an ex-smoker, having quit in 1994. He was described by his personal physician, many fire

fighters, and his widow as very physically fit, with weight-lifting and jogging as part of his fitness regimen three to four times per week. He had no other illnesses and no family history of cardiovascular disease.

Pertinent findings from the autopsy, performed by the medical examiner on February 4, 1998, are listed below:

- Large recent anterior myocardial infarction
- Coronary artery disease
 - Left anterior descending coronary artery: proximally contains a 1-inch wire mesh with numerous plaques and 50% obstruction; distal end is clear and free of disease
 - Right coronary artery: 75% obstruction
 - Circumflex branch: up to 35% obstruction
- A moderate amount of soot coating the larynx and trachea consistent with smoke inhalation
- The victim's carbon monoxide level was 2.5% upon ED arrival
- Laceration and contusions of the right forehead consistent with injuries from a terminal fall

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the fire department was comprised of 2,432 uniformed personnel and served a population of 1,480,000 residents, in a geographic area of 130 square miles. Fire fighters in 60 fire stations work the following tour of duty: Day 1, 0800-1800; Day 2, 0800-1800; Day 3, 1800-0800; Day 4, 1800-0800; off duty for 4 days. There are 4 platoons. Each shift of an engine company is staffed with an officer and three fire fighters; each ladder company, an officer and four fire fighters. The emergency medical service is a component of the fire department.



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In 1998, the department responded to 220,565 total calls: 163,208 total medical incidents and 57,357 total fire and emergency service incidents (36,456 other responses [police assist, medical assist, citizen assist, malfunctioning equipment], 9,890 nonstructure fires, 8,151 false alarms, and 2,860 structure fires). Total calls included 22 multiple alarm fires.

The day of the incident, the victim began his shift at 0800 hours, his first day back after the 4-day break. The day was spent checking out the equipment and performing station maintenance and paperwork during which the victim did not report or show signs of discomfort, pain, or distress. The incident described was the victim's first emergency response during his shift.

The building involved in this incident was a deteriorated, three-story, end-of-the-row type, ordinary construction, brick and masonry exterior, and measured 15 feet by 45 feet. Water leaks through the roof had caused structural damage to all floors. There was no electrical or gas service to the building. The occupant used kerosene as fuel for heating, cooking, and lighting. Garbage was strewn throughout the dwelling and, in addition to the occupant, numerous dogs were living in the dwelling. The fire was caused by a portable kerosene heater igniting nearby combustibles.

Training. The fire department provides all new fire fighters with the basic 15-week recruit training, conducted at the city's Fire Academy, to become certified Fire Fighters. All fire fighters are defibrillator- and Emergency Medical Technician (EMT)- certified. The victim had 22 years of fire fighting experience and was a certified Fire Fighter. He was promoted to Lieutenant in 1994, and he had been assigned to Ladder 1 thirteen days before his collapse.

Preemployment/Preplacement Evaluations. The department requires (1) a preemployment/preplacement medical evaluation for all new hires, (2) a physical examination when a fire fighter is promoted, and (3) a physical examination when a fire fighter is off duty for illness/injury for 14 days. Components of this evaluation for all applicants include

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Vision test
- Hearing test
- Complete blood count (CBC)
- Cholesterol and triglycerides
- Urinalysis
- Urine drug test
- Pulmonary function tests (lung tests)
- Resting electrocardiogram
- Stress electrocardiogram
- Chest X-ray

These evaluations are performed by the City Medical Director, with pass/fail results distributed to the fire department. Once this evaluation is completed, a decision regarding medical clearance for fire fighting duties is made by the Medical Director. New hires are also required to complete a physical capacity test at the city Fire Academy. This is a nontimed performance evaluation of typical fire fighting duties.

Periodic Evaluations

No routine annual/periodic medical evaluations are required by this department for all fire fighters. If employees are injured at work, they must be cleared for "return to work" by the city Medical Director. Additionally, medical evaluations are conducted every 2 years for fire fighters assigned to the hazardous materials unit and for fire fighters who are promoted. The contents of the examination are the same as the preemployment/preplacement evaluation.



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Annual/periodic physical capacity tests are not required by this department. Some fire stations have exercise (strength and aerobic) equipment, typically purchased by the fire fighters themselves. The department has voluntary smoking cessation and weight control programs but no required fitness/wellness program and no specific required medical clearance for SCBA use.

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 five of the risk factors for coronary artery disease: male gender, advancing age, hypertension (controlled by medication), borderline high cholesterol, and history of smoking). An autopsy revealed he had moderate to severe atherosclerotic disease in his 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. The victim did have a significant blood clot (thrombosis) identified during the emergency cardiac catheterization and at autopsy.

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.⁶⁻⁸ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.⁹⁻¹² The mental and physical stress of responding to the emergency, carrying a 16-foot portable ladder for 195 feet, climbing the ladder to the second floor in his bunker gear, breaking out two windows, and entering a smoke-filled building (with undetermined by-products of combustion) without SCBA, along with his previously undiagnosed underlying atherosclerotic coronary artery disease, all probably contributed to this victim's heart attack, cardiac arrest, and sudden cardiac death.

This victim did not report prior episodes of angina (heart pain) during physical activity performed on or off the job. However, sudden cardiac arrest is often the first overt manifestation of ischemic heart disease.¹³

Discrepancies occurred between the frequency and content of the Department's medical evaluation and those recommended by the NFPA.¹⁴ For example, the Department conducted extensive preemployment/preplacement medical evaluations, including treadmill stress tests on all applicants, regardless of age. The NFPA recommends stress tests for those 35 years old and above with known CAD risk factors and 40 years old and above for those without CAD risk factors. The tests should be conducted at least every 2 years.

The NFPA also recommends annual medical evaluations with periodic medical examinations. Stress tests are included as part of these medical examinations. If a treadmill test had been performed on this Fire Fighter in the 2 years prior to his death, his underlying CAD would likely have been identified, and he would then have been directed toward further evaluation and treatment.¹⁵



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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 listed in a priority manner.

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 scheduling of periodic medical evaluations for fire fighters can be found in *NFPA 1582, Standard on Medical Requirements for Fire Fighters*,¹⁴ and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs wellness/fitness initiative.¹⁶ The department is not legally required to follow any of these standards. Nonetheless, we recommend the City and Union **negotiate** the content and frequency to be consistent with the above guidelines.

Specifically, the preemployment/preplacement stress (EKG) tests are not necessary for applicants under the age of 35. Additionally, the use of chest X-rays in surveillance activities in the absence of significant exposures, symptoms, or medical findings has not been shown to reduce respiratory or other health impairment.¹⁴ Therefore, only preemployment/preplacement chest X-rays are recommended. These tests can be harmful, and they do represent

an unnecessary expense for the department. On the other hand, annual/periodic medical evaluations should be conducted and should include stress tests beginning at age 35 for fire fighters with risk factors for CAD. Although this victim routinely saw a personal physician, no stress test had been conducted, nor was there a medical reason to perform one. 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 issues, so it should be carried out in a **confidential, nondiscriminatory** manner. Appendix D of NFPA 1582 provides guidance for Fire Department Administrators regarding legal considerations in applying the standard.

Applying NFPA 1582 also 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*, addresses these issues in Chapter 8-7.1 and 8-7.2.¹⁷

The success of medical programs hinges on protecting the affected fire fighter. The department must (1) keep the medical records confidential, (2) provide alternate duty positions for fire fighters in rehabilitation programs, and (3) if the fire fighter is not medically qualified to return to active fire fighting duties, provide permanent alternate duty positions or other supportive and/or compensated alternatives.

Recommendation #2: Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by phasing in a mandatory wellness/fitness program for fire fighters.



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NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.¹⁷ 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.¹⁶ The Fire Department and the Union should review these materials to identify applicable elements for their department. Other large-city negotiated programs can also be reviewed as potential models. It was reported that the victim had been aerobically and physically fit. The City had voluntary smoking cessation and weight control programs; however, no mandatory wellness/fitness program was in place.

Recommendation #3: All personnel entering a potentially hazardous atmosphere should wear an SCBA.

An SCBA should be worn when a fire fighter enters an area that is considered immediately dangerous to life or health (IDLH), potentially IDLH, or where the atmosphere is unknown.¹⁷ Smoke, vapor or fumes from a fire or hazardous incident may contain many toxic components. Some of these components will have immediate effects on the unprotected fire fighter, while others are cumulative, with adverse health effects caused by years of exposure. SCBA provided to fire fighters should be of a type that allows the fire fighter both adequate protection from hazardous and toxic components and the ability to effectively communicate with other fire fighters and victims of fires. All members of this fire department

in an active-duty status are required to wear SCBA in compliance with the department's mandatory SCBA policy. In this incident, however, the victim was not wearing an SCBA.

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