



Fire Fighter Dies as a Result of a Cardiac Arrest as He Returns From a Gas Leak at a Single-Family Dwelling - Oklahoma

SUMMARY

On February 11, 1998, a 48-year-old male Fire Fighter responded with his engine crew to a reported gas leak in a single-family dwelling. At the scene the victim was noted to be slightly short of breath but not in acute distress. After approximately 15 minutes on scene, the engine crew returned to the fire station where the victim was noted to be unresponsive in his cab seat. Cardio-pulmonary resuscitation (CPR) was begun as a second engine company and ambulance were requested for a suspected cardiac arrest. Upon arrival, paramedics with the ambulance service provided advanced life support (ALS) and CPR on scene for a total of 20 minutes before embarking to the hospital. ALS and CPR were continued en route to the hospital and in the hospital's emergency department (ED). After approximately 10 minutes in the ED, the victim was pronounced dead, and resuscitation measures were discontinued. The death certificate completed by the medical examiner listed "coronary sclerotic heart disease" as the immediate cause of death. The autopsy report, also completed by the medical examiner, listed the final diagnosis as "marked coronary atherosclerosis, cardiomegaly, and pulmonary congestion and edema."

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. Following are issues relevant to this fire department:

- *Provide adequate fire fighter staffing to ensure safe operating conditions.*

- *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.*

INTRODUCTION & METHODS

On February 11, 1998, a 48-year-old male Fire Fighter lost consciousness as he returned to the fire station after responding to a reported gas leak at a single-family dwelling. Despite CPR and ALS administered by members of his crew, a neighboring engine company, ambulance paramedics, and emergency room personnel, the victim died. NIOSH was notified of this fatality on February 15, 1998, by the United States Fire Administration. On October 26, 1998, NIOSH telephoned the affected Fire Department to initiate the investigation. On November 4, 1998, a Safety and Occupational Health Specialist and a Senior Medical

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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Epidemiologist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Oklahoma to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel met with and interviewed

- A Local Vice-President of the International Association of Fire Fighters (IAFF)
- A City Safety and Health Analyst who completed the Fire Department investigation
- Fire Fighters involved in this incident
- Family members
- A Fire Department Training Officer

During the site visit NIOSH personnel also reviewed

- Existing Fire Department investigative records, including incident reports, co-worker statements, dispatch records, and the victim's medical evaluations conducted for the Fire Department
- Fire Department policies and operating procedures
- Fire Department training records
- The Fire Department annual Injury and Accident 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 examiner who performed the autopsy.

INVESTIGATIVE RESULTS

Gas Leak Response. On February 11, 1998, at 1302 hours, Engine 17 was dispatched on a still alarm (single engine response) to a reported gas leak at a single-family dwelling located approximately ½ mile from their fire station. At the time, Engine 17 was staffed by three fire department employees (Acting Captain, Relief Driver/Operator, and a fire fighter [victim]). Engine 17 responded at 1303 hours and arrived on scene at 1305 hours. The victim was instructed to shut off the natural gas at the meter. Wearing bunker pants and boots, the victim proceeded about 100 feet to the meter, turned off the gas supply, and returned to the front of the residence. The two other crew members entered the residence, found the leak, and plugged the hole. Once this task was completed, the victim was instructed to turn on the gas supply. When the victim returned to the front of the residence after turning on the gas supply, the crew noticed he was breathing heavily and looked fatigued. Engine 17 departed the scene at 1315 hours and arrived back at the fire station at about 1320 hours. The Engine turned around in the driveway and prepared to back into the fire station.

Upon returning to quarters, the victim's normal duty is to get off the Engine, enter the fire station, open the overhead door, and guide the Engine back into quarters. However, on this occasion, he did not get off the Engine. The Relief Driver/Operator and the Acting Captain turned around to look at the victim to ascertain what was wrong and saw the victim shrug his shoulders twice. The Acting Captain ran inside the station to request an ambulance and an additional engine company. After placing the call, the Acting Captain went back outside to assist the Relief Driver/Operator in removing the victim from



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the Engine and laying him on the driveway for evaluation. Initial assessment revealed no pulse or respirations, and CPR was initiated.

At 1321 hours, Engine 15 was dispatched to assist Engine 17. At 1322 hours, the ambulance was dispatched. Engine 15 arrived on scene at 1324 hours and the ambulance arrived shortly thereafter. While CPR was being maintained, an automatic external defibrillator (AED) was connected to the victim to analyze his heart rhythm. His heart was in a ventricular fibrillation rhythm, and one shock was delivered at 1326 hours. A palpable peripheral (femoral) pulse was gained for a short time but was not maintained. The victim was intubated and medications consistent with advanced life support (ALS) protocols were given. CPR and ALS measures were continued for 18 minutes on site and during the 8-minute ambulance ride to the hospital.

The ambulance arrived at the hospital at 1352 hours. Once inside the emergency department, the victim was reassessed and again found to be unconscious, pulseless, and without spontaneous respirations. The placement of the endotracheal tube was rechecked and found to be in the proper position. His initial heart rhythm was asystole. ALS measures were continued. An acute myocardial infarction was suspected and a thrombolytic agent was administered into the victim's intravenous line without a change in his cardiac status. He was pronounced dead at 1405 hours.

The Engine crew began their shift at 0700 hours (early relief). The morning was spent "changing out the truck" (switching all equipment and hose to a reserve apparatus), which entailed a significant amount of physical exertion. While performing this work, the victim did not report or show signs of discomfort, pain, or distress. The gas leak incident at 1300 hours was the crew's first emergency response during their shift.

Medical Findings. The death certificate was completed by the medical examiner who listed "coronary sclerotic heart disease" as the immediate cause of death. Blood tests in the emergency department revealed a normal carboxyhemoglobin level, indicating that the deceased was not exposed to excessive concentrations of carbon monoxide prior to his death. A blood alcohol and drug screen were also found to be negative.

Pertinent findings from the autopsy, performed by the medical examiner on February 12, 1998, are listed below:

- 50% narrowing of the right coronary artery
- 65% narrowing of the left anterior descending coronary artery
- Moderately enlarged heart (cardiomegaly)
- No evidence of a thrombus formation in any of the coronary arteries
- No evidence of significant valvular or electrical heart problems
- Pulmonary congestion and edema most likely secondary to this heart attack

Medical records indicated that the victim had several risk factors for coronary artery disease (CAD). In 1982 the victim had an exercise treadmill test as part of the fire department's medical screening program for new or recently rehired Fire Fighters. At that time he showed no evidence of ischemic heart disease. In 1984 the victim was assessed in a local emergency department for an episode of chest pain. A normal EKG and the pain characteristics resulted in a diagnosis of chest pain of gastrointestinal origin ("heartburn"). These were the last screening tests this individual had for CAD. In 1997, the City



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Physician cleared the victim for fire fighting activities without restrictions. The victim's family reported that he maintained a small amount of aerobic activity off the job and did not report chest pain.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the fire department was comprised of 711 uniformed personnel and served a population of 384,000 in a geographic area of 191 square miles. There are 30 fire stations, where fire fighters work 24 hours on duty (0800 hours to 0800 hours) and are off 48 hours. On each shift an engine company is staffed with four crew members; however, due to vacation, sick days, or city shift (Kelly Day), the engine company is frequently staffed with a minimum of three fire fighters. The victim was normally assigned to Station 31; however, due to personnel shortages on the day of the incident, he was reassigned to Station 17.

In 1997, the department responded to 28,100 total calls: 13,756 for emergency medical services (EMS), 7,389 "other" incidents, 3,270 false alarms, 2,534 fires, 914 hazmat, and 237 mutual aid responses.

Training. The fire department provides all new fire fighters with the basic 320-hour recruit training required by the State of Oklahoma to become certified to the NFPA Fire Fighter Level I and II. The department follows the International Fire Service Training Association (IFSTA) curriculum. The department also recommends 20 hours of additional on-the-job training each month. The training is provided primarily "in service" by the company officers of each engine company. The victim had 23 years of fire fighting experience and was a state certified Fire Fighter.

Medical Evaluations. The frequency and components of the medical evaluation were

negotiated between the city and the union representing the fire fighters. In 1998 this included the following components (as listed in the negotiated contract) on an annual basis by the City Physician:

- A complete history
- Height, weight, and vital signs
- Physical examination of the head, eyes, ears, nose, throat, heart, lungs, abdomen, genitals, and digital rectal examination
- Vision testing and ophthalmoscopic examination
- Chest X-ray
- Electrocardiogram (EKG)
- Urinalysis and a battery of blood chemistries including Hepatitis C screening when warranted
- Treadmill test (employee's option)

The employee could opt for his/her personal physician to perform this evaluation if "a letter from his [personal] physician was provided to the City Physician stating that he has undergone a comparable physical and the results thereof (e.g., in good health, etc.)." The City Physician's office would also conduct hearing and spirometry (lung) tests which would provide medical clearance for the Fire Fighter to (1) wear a respirator (SCBA), and (2) perform fire fighting duties with or without restrictions.

The City Physician's office informed the NIOSH investigators that this Fire Fighter had opted for his personal physician to conduct the medical evaluation. Unfortunately, the personal physician performed only some of the components listed above, and none were conducted on an annual basis. No records could be found stating that the personal physician sent the City



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Physician a letter with evaluation results or a statement of good health.

Physical Fitness

Like the medical evaluation program, a health, wellness and safety program was negotiated between the city and the union representing the fire fighters. A Health, Wellness, and Safety Committee with equal representation from the fire department and the union was selected to develop initial recommendations for a comprehensive physical fitness testing program. This program is mandatory for all fire fighters hired after July 1, 1995, and voluntary for those hired prior to this date. A voluntary program for incumbent employees ensures that employees are not negatively impacted by newly developed employment conditions. All fire fighters, both incumbent and newly hired, who enter and pass various components of the physical ability test receive a modest monetary incentive.

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 some of these risk factors. The autopsy showed that the victim had moderate atherosclerotic coronary artery disease in two of 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. In the autopsy, the victim did not have a blood clot (thrombosis) identified by the medical examiner; however, this is consistent with the victim receiving a thrombolytic drug in the emergency department to dissolve blood clots.

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 precedes and triggers the onset of acute heart attacks.⁸⁻¹¹

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 to persist through the course of fire suppression activities.¹²⁻¹⁴ The mental and physical stress of responding to the fire department alarm, jogging in his bunker gear to turn off the gas supply, and his 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. Unfortunately, sudden cardiac death is a common presenting manifestation of ischemic heart disease.¹⁵



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There were differences in the frequency and content of the City's negotiated medical evaluation and those recommended by the NFPA.¹⁶ For example, the City conducted annual medical examinations on all Fire Fighters, while the NFPA recommends annual examinations for those 40 and older, biannual examinations for those 30 to 39, and exams every 3 years for those less than 30. The content of the medical examination also differed slightly, most notably with respect to exercise EKG tests, sometimes known as stress, or treadmill, tests. The City gives the employee the option of an exercise EKG test, while the NFPA recommends periodic exercise EKG tests beginning at age 40. If the Fire Fighter has one or more risk factors for CAD, the NFPA recommends beginning periodic testing at age 35. The degree of coronary artery disease in the victim at the time of his autopsy suggests that an exercise EKG test within the preceding year would have shown evidence of this disease.¹⁷

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

On the day of the incident, three crew members were on duty. Based on interviews conducted during this investigation, this is not an uncommon occurrence. Nonetheless, 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.¹⁸ 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 Oklahoma 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, on vacation, or on city shift (Kelly Day); and (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: 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 annual/periodic medical evaluations for fire fighters can be found in NFPA Standard 1582, 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.¹⁹ As discussed previously, the department is not legally required to follow these standards. Nonetheless, we recommend the City



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and Union negotiate the content and frequency to be consistent with the above organizations. If the provision allowing personal physicians to conduct this evaluation and examination continues, efforts should be made to improve communication between the personal physician's office and the City Physician's office. The City Physician should not provide medical clearance in the absence of records documenting the results of the required examinations.

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

We applaud recent efforts by the department's Health, Wellness, and Safety Committee to implement a wellness and fitness program. Assistance for various components of this program are available from the NFPA (Standard 1500,²⁰ and a joint report from the International Association of Fire Fighters and the International Association of Fire Chiefs Fire Service Joint Labor Management Wellness/Fitness Initiative.¹⁹

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INVESTIGATOR INFORMATION

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