



Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

December 29, 2006

Career Airport Fire Apparatus Operator Suffers Sudden Cardiac Death At His Station After Exercising – Georgia

SUMMARY

On April 16, 2006, a 39-year-old male career airport Fire Apparatus Operator (FAO) arrived for duty at his station around 0700 hours. Throughout his shift, he performed normal station training and duties and did not respond to any calls. He went to exercise at about 2100 hours, but his station was alerted with a call at approximately 2200 hours. When he heard the apparatus siren, he ran into the vehicle bay thinking it was his apparatus. When he realized his vehicle was not needed, he returned to the exercise room. He walked into the day room approximately 5 minutes later, said he needed help, and fell to the ground. An advance life support ambulance was summoned; when it arrived the paramedics found him alert and oriented lying on the floor holding his chest and complaining of pain. The paramedics performed a 12-lead electrocardiogram (EKG), which indicated the FAO was having an acute myocardial infarction (MI). The FAO was transported to the Emergency Department (ED) and quickly transferred to the cardiac catheterization lab where his proximal left anterior descending artery showed a 100% blockage. A stent was placed that completely eliminated the blockage, but his clinical course was complicated by aspiration pneumonia and persistent hypotension. Despite 9 days of intensive care, his cardiac and respiratory function never improved and he died on April 25, 2006.

The FAO's death certificate lists his immediate cause of death as "Acute Respiratory Distress Syndrome due to an acute myocardial infarction." The autopsy revealed a massive MI. The NIOSH investigator concluded the FAO's strenuous exercise while on-duty, coupled with the response to the activation alarm, and his underlying coronary artery disease (CAD) triggered his MI, which led to his death.

NIOSH investigators offer the following recommendations to prevent similar incidents and to address general safety and health issues:

Collaborate with the local union to develop a wellness/fitness program consistent with National Fire Protection Association (NFPA) 1583, Standard on Health-Related Fitness Programs for Fire Fighters and/or the Fire Service Joint Labor Management Wellness/Fitness Initiative.

Funding for the Wellness/Fitness Program described above should be secured by the FD from the governing municipality.

Consider symptom limiting Exercise Stress Test for fire fighters at increased risk for CAD and SCD.

Negotiate with the local union to phase in an annual physical ability test.

INTRODUCTION & METHODS

Late in the evening on April 16, 2006, a 39-year-old male career airport FAO suffered an MI and died 9 days later. On May 5, 2006, NIOSH contacted the affected Fire Department (FD) to gather information pertaining to the fatality. On August 2, 2006, an Occupational Advanced Practice Registered Nurse

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. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. 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 Web site at

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Career Airport Fire Apparatus Operator Suffers Sudden Cardiac Death At His Station After Exercising – Georgia

from the NIOSH Fire Fighter Fatality Investigation and Prevention Team traveled to Georgia to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- FD personnel
- FAO's wife
- Local Union officials

During the site visit, NIOSH personnel reviewed the following documents:

- FD policies and operating guidelines
- FD wellness program
- FD training records
- FD annual report for 2005
- FD incident reports
- Hospital records
- Medical records
- Autopsy report
- Death certificate
- FAO's fitness evaluation and exercise prescription conducted by the FD contractor

INVESTIGATIVE RESULTS

On April 16, 2006, a 39-year-old male career airport FAO arrived for duty at his station around 0700 hours. Throughout his shift, he performed normal station training (non-strenuous classroom instruction) and duties, but did not respond to any calls. At about 2100 hours, he began exercising. His normal work-out routine included stretching exercises followed by strenuously running on an elliptical trainer. On some occasions he lifted free weights, but on this night he appeared to run only. At approximately 2200 hours, another apparatus at his station was toned out for a call. The exercising FAO rushed into the apparatus bay, but realized his vehicle was not needed, returned to the exercise room. About 5 minutes later, he walked

into the day room saying he needed help and then fell to the ground.

At about 2205 hours, an advanced life support medic unit was summoned as the FAO complained of severe chest pain and left arm pain. Crew members retrieved a "jump bag," containing oxygen and the automatic external defibrillator, from a vehicle in the apparatus bay. However, before the automatic external defibrillator could be applied, the dispatched ambulance arrived. The paramedics found the FAO alert and oriented, lying on the floor holding his chest and complaining of pain. He was cold, clammy, diaphoretic, and ashen. The FAO was put on oxygen by mask; a 12-lead EKG showed sinus rhythm with elevated ST segments (a sign of acute myocardial injury known as a heart attack or acute MI). Two intravenous lines were started and he was loaded into the ambulance and transported to the hospital at approximately 2215. Medications consistent with ALS protocols were followed for an acute MI while en-route to the hospital. When the FAO arrived at the ED at 2300 hours, he was still complaining of chest pain and shortness of breath. An electrocardiogram (EKG) showed ST segment elevation in multiple leads, indicative of an MI. After discussion with a cardiologist, the FAO underwent an emergency cardiac catheterization at 0004 hours (2 hours after he collapsed). The cardiac catheterization showed 100% blockage of a prominent coronary artery (proximal left anterior descending artery) and a stent was successfully placed. His left ventricular function was estimated to be 20% (normal generally > 50%) and an intra-aortic balloon pump was inserted to maintain his blood pressure. While under sedation during the procedure, the FAO aspirated on his vomitus. He was successfully intubated (a breathing tube inserted into the windpipe) and placed on a ventilator. During the subsequent 9 days of intensive care, the FAO remained in cardiogenic shock (extremely low blood pressure due to the heart's inability to pump blood throughout the body). This heart failure was confirmed by an echocardiogram on April 17 showing left ventricular hypertrophy and a left ventricular function of 15%. In addition, the FAO's lung status deteriorated due to either the cardiogenic shock or his



Career Airport Fire Apparatus Operator Suffers Sudden Cardiac Death At His Station After Exercising – Georgia

aspiration pneumonia. On April 25, 2006, the FAO suffered a cardiac arrest and died.

Medical Findings. The FAO's death certificate (completed by the attending physician) lists the immediate cause of death as "Acute Respiratory Distress Syndrome due to an acute myocardial infarction (MI)." An autopsy was performed on April 26, 2006. Pertinent findings from the autopsy included the following:

- Acute MI
 - Massive infarct of the left ventricle, extending from the apex to the base of the heart
 - Focal acute extension of the infarct
 - Stent in place, proximal left anterior descending coronary artery, with a luminal thrombus
- Atherosclerotic CAD
 - Moderate to severe atherosclerosis of distal left anterior descending artery
 - Moderate atherosclerosis of right coronary artery
 - Moderate atherosclerosis of circumflex artery
- Cardiomegaly (enlarged heart): heart weight of 600 grams (g) (the normal weight given in the autopsy records is 250-350 g)
- No pulmonary embolus

The FAO's pre-hire medical examination 19 years earlier (1987) was unremarkable. No medical records were found for the period between 1987 and 2003. In October 2003, the FAO had a physical exam conducted by his primary care provider (PCP), who noted hyperlipidemia:

- Total cholesterol was 305 mg/dL (normal is <200 mg/dL),
- Low-density lipoprotein (LDL) cholesterol was 211 mg/dL (normal is <130 mg/dL), and
- Triglycerides were 221 milligrams/deciliter (mg/dL) (normal is <150 mg/dL).

He was given a cholesterol-lowering agent, but when he returned 3 months later, he reported discontinuing the medication due to its side effects. He was given a new lipid lowering medication and by April 2004 his total cholesterol and LDL cholesterol levels were improved, but still elevated (266 and 187 mg/dL respectively). Over the next 2 years he had variable compliance with his lipid lowering medications and was never able to get his total cholesterol or LDL cholesterol into the normal range.

In June 2005, the FAO had a FD medical evaluation which confirmed his elevated total and LDL cholesterol and triglycerides. A bicycle ergometer exercise stress test (EST) was performed, but the FAO only achieved 82% of his maximum heart rate before the test was terminated. He did not express any angina, nor express any symptoms terminating the test early (the outside contractor typically tests FFs to 85% of their maximum heart rate). Nonetheless, the FAO had a good BP response, no arrhythmias, and no EKG changes suggestive of CAD. He was cleared for firefighting duty by the FD contract physician.

The FAO exercised on a regular basis and reached an estimated 11 metabolic equivalents or a VO_{2max} (mean volume of oxygen consumed per unit of time) of 38.5 milliliters/minutes per kilogram of body weight. On autopsy he was 69 inches tall and weighed 202 pounds. This gave him a body mass index (BMI) of 30 kilograms per meters²(kg/m²)¹. A BMI of 30.0-39.9 kg/m² is considered obese,¹ although this simple method of determining obesity has been criticized because it may overestimate body fat in individuals with a muscular build.² Therefore, the FAO had two, possibly three risk factors for CAD (male gender, high blood cholesterol, and borderline obesity).

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this career FD consisted of 998 uniformed personnel, served a population of 450,000 in a 144 square-mile area, and had 35 fire stations.



Career Airport Fire Apparatus Operator Suffers Sudden Cardiac Death At His Station After Exercising – Georgia

In 2005, the FD responded to 23,640 calls: 38% for fires, 44% for rescue, 8% for hazardous materials, 8% for service, and 2% for false calls.

Employment and Training. Candidates for employment must fill out an application, then pass a general aptitude test, physical ability test, polygraph test, and background check. They are then provisionally hired until they complete a medical evaluation. The recruit class is formed and attends a 6-month Academy, where they are trained to Intermediate Emergency Medical Technician and Fire Fighter-I levels. If the recruit is already a Fire Fighter-I and an Intermediate Emergency Medical Technician, the recruit must only attend the Academy for 30 days. Recruit fire fighters are then assigned to a station, where further training to Fire Fighter-II level is conducted until the Fire Fighter-II examination has been passed.

Pre-placement Medical Evaluations. A pre-placement medical evaluation is required by this FD for all applicants. The contents of the examination are as follows:

- Complete medical and occupational history
- Height, weight, and vital signs
- Physical examination
- Blood tests: comprehensive metabolic panel, lipid panel, and liver profile
- Urine tests: urinalysis and urine drug screen
- Chest x-ray (posteroanterior and lateral views) with interpretation and report
- 12-lead resting EKG with interpretation and report
- Treadmill Exercise Stress Tests
- Spirometry
- Audiometry
- Vision test

These evaluations are performed by a physician under contract to the City. Once this evaluation is complete, the physician makes a determination

regarding medical clearance for firefighting duties and forwards this decision to the FD.

Periodic Evaluations. In 2005, the FD began a program of required annual medical evaluations with a physician statement regarding the FF's medical and fitness for duty. The contents of the examination are as follows:

- Complete medical and occupational history
- Height, weight, and vital signs
- Physical examination
- Blood tests: comprehensive metabolic panel, lipid panel, and liver profile
- Urine tests: urinalysis
- 12-lead resting EKG with interpretation and report
- Bicycle ergometer Exercise Stress Test
- Spirometry
- Audiometry
- Vision test

Health/Wellness. An annual physical agility test is not required for members. The FD has a voluntary fitness program and exercise equipment (strength and aerobic) is available in all fire stations. A return-to-duty medical clearance is required from the City-contracted physician for all duty-related injuries. Fire fighters who miss more than two shifts due to illness are required to have a release from their PCP before they may return to work. Smoking cessation programs are available from the department.

DISCUSSION

The FAO's death was due to complications of an acute MI. The MI was confirmed by EKG changes (ST segment elevation), elevated cardiac enzyme elevation, and the thrombus found in the left anterior descending coronary artery during his cardiac catheterization. The complications included cardiogenic shock and aspiration pneumonia.



Career Airport Fire Apparatus Operator Suffers Sudden Cardiac Death At His Station After Exercising – Georgia

CAD and the Pathophysiology of MI. In the United States, CAD (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.³ Risk factors for CAD include age over 45, male gender, family history of CAD, smoking, high blood pressure (systolic >140 millimeters of mercury (mmHg) or diastolic >90 mmHg), high blood cholesterol (total cholesterol >240 mg/dL), obesity/physical inactivity, and diabetes.^{4,5} The FAO had at least two, possibly three, of these risk factors (male gender, obesity, and borderline high blood cholesterol).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.⁶ However, the growth of these plaques probably occurs in a non-linear, often abrupt fashion.⁷ 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.⁸ This sudden blockage is primarily due to blood clots (thromboses) forming on the top of atherosclerotic plaques. The FAO was shown to have a thrombus in his left anterior descending artery.

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 responding to the initial alarm and persist through the course of fire suppression activities.⁹⁻¹¹ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.¹²⁻¹⁵ The physical stress of exercising (as part of a required non-punitive FD fitness program), coupled with his response to the alarm, and his underlying atherosclerotic CAD, triggered the FAO's heart attack and eventual death.

Left Ventricular Hypertrophy. On autopsy, the FAO was found to have an enlarged heart. The echocardiogram completed post-stenting identified mild left ventricular hypertrophy. Left ventricular hypertrophy is a relatively common finding among

individuals with chronic cardiac ischemia (reduced blood supply to the heart muscle), a heart valve problem or long-standing high blood pressure (hypertension). On autopsy, the FAO's heart valves were normal, and he had no history of hypertension. Therefore, the most likely etiology of his LVH and cardiomegaly was chronic cardiac ischemia. This is consistent with the autopsy findings of moderate to severe atherosclerotic disease in all three of his main coronary arteries. Although LVH is associated with an increased risk of sudden death, the massive heart attack is responsible for this FAO's death.

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the NFPA developed NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments*.¹⁶ NFPA 1582 (2003 Edition) recommends that, as part of its annex which is for informational purposes only, asymptomatic fire fighters with two or more risk factors for CAD be screened for obstructive CAD by an exercise stress test. The NFPA defines these CAD risk factors as: family history of premature cardiac event (first-degree relative <age 60), hypertension (diastolic blood pressure >90 mmHg), diabetes mellitus, cigarette smoking, and hypercholesterolemia (total cholesterol >240 mg/dL).¹⁶ This guidance is similar to recommendations from the American College of Cardiology (ACC)/American Heart Association (AHA) and the Department of Transportation regarding exercise stress tests for asymptomatic individuals.^{17,18} Since the FAO had two of the NFPA's CAD risk factors (family history and hypercholesterolemia), an exercise stress test would have been consistent with NFPA 1582 guidance. In the NFPA 1582 annex, a submaximal EST using a treadmill, bicycle, or stair climber is approved.¹⁶ On this point, NFPA 1582 is not consistent with recommendations from the ACC/AHA. The ACC/AHA recommends other exercise endpoints (eg., symptom limiting) rather than an arbitrary percentage of predicted maximum heart rate.¹⁷



Career Airport Fire Apparatus Operator Suffers Sudden Cardiac Death At His Station After Exercising – Georgia

In September 2005, the FAO had a submaximal exercise stress test which showed no signs of ischemia. This probably represented a false negative result; a well recognized and accepted limitation of the exercise stress test. It is unlikely that the exercise stress test would have become positive if the FAO exercised to 85%, not 82%, of his maximum predicted heart rate. Nonetheless, a symptom limiting exercise stress test may have resulted in a positive test and the FAO could have been referred to a cardiologist for further evaluation and treatment. With intervention, his acute MI may have been prevented at this time.

RECOMMENDATIONS

NIOSH investigators offer the following recommendations to prevent similar incidents and to address general safety and health issues:

Recommendation #1: Continue collaboration with the local union to develop a wellness/fitness program consistent with NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters¹⁹ and/or the Fire Service Joint Labor Management Wellness/Fitness Initiative²⁰.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Additionally, physical inactivity (or lack of exercise) is associated with other risk factors: obesity and diabetes.²¹ NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, and NFPA 1583 require a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.^{19,22}

In 1997, the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) published a comprehensive *Fire Service Joint Labor Management Wellness/Fitness Initiative* to improve fire fighters' quality of life and maintain physical and mental capabilities of fire fighters. Ten FDs across the United States joined this effort to pool

information about their physical fitness programs and create a practical fire service program. They produced a manual and a video which detail elements of such a program.²⁰ We recommend the FD and union review these materials to identify applicable elements. Other large-city negotiated programs can also be reviewed as potential models.

Recommendation #2: Funding for the Wellness/Fitness Program described above should be secured by the FD from the governing municipality.

Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.²³⁻²⁵ A similar cost savings has been reported by the wellness program at the Phoenix FD, where a 12-year commitment has resulted in a significant reduction in disability pension costs.²⁶

Recommendation #3: Consider symptom limiting exercise stress test for FF at increased risk for CAD and SCD.

NFPA 1582 and the IAFF/IAFC wellness/fitness initiative recommends exercise stress tests for fire fighters with two or more CAD risk factors.^{16,20} The AHA states exercise stress tests may be indicated for individuals with two or more risk factors for CAD who are over 45 years of age.¹⁷ As mentioned earlier, this FAO had a submaximal EST. Although he had no signs of ischemia on the EKG, he still only achieved 82% of his maximum heart rate. It is possible a symptom limiting exercise stress test may have identified his underlying CAD and led to therapeutic CAD procedures. The American College of Cardiology/American Heart Association (ACC/AHA) recommends conducting EST with increasing speed and grade, terminating when symptoms appear, rather than at an arbitrary percentage of predicted maximal heart rate.¹⁷

Recommendation #4: Negotiate with the local union to phase in an annual physical ability test.



Career Airport Fire Apparatus Operator Suffers Sudden Cardiac Death At His Station After Exercising – Georgia

NFPA 1500 requires FD members who engage in emergency operations to be annually evaluated and certified by the FD as meeting the physical performance requirements identified in paragraph 8-2.1 of the standard.²²

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Career Airport Fire Apparatus Operator Suffers Sudden Cardiac Death At His Station After Exercising – Georgia

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