



Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

December, 2007

Fire Fighter-Emergency Medical Technician Suffers Sudden Cardiac Death During Physical Fitness Training – Nevada

SUMMARY

On August 8, 2006, a 49-year-old male career Fire Fighter-Emergency Medical Technician (FF-EMT) was participating in the Fire Department's voluntary physical fitness program. The FF-EMT had walked on the treadmill for approximately 20 minutes when he suddenly collapsed. Crew members in the fire station found him unresponsive, not breathing, and without a pulse. Approximately 38 minutes later, despite cardiopulmonary resuscitation (CPR) and advanced life support administered on-scene and at the hospital, the FF-EMT died. The death certificate and the autopsy (completed by the County Medical Examiner) listed "atherosclerotic cardiovascular disease" as the cause of death. The NIOSH investigator concludes the FF-EMT's exercise on the treadmill, coupled with his underlying atherosclerotic coronary artery disease, triggered his sudden cardiac death.

The NIOSH investigator offers the following recommendations to address general safety and health issues. It is unlikely these recommendations would have prevented the FF-EMT's sudden cardiac death.

- *Develop a structured comprehensive wellness/fitness program to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.*

- *Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural firefighting.*
- *Eliminate or reduce the frequency of periodic chest x-rays in asymptomatic fire fighters, unless clinically indicated.*

INTRODUCTION & METHODS

On August 8, 2006, a 49-year-old male FF-EMT lost consciousness while participating in his Fire Department's physical fitness program. Despite CPR and advanced life support administered by crew members, the Fire Department ambulance crew, and in the Emergency Department, the FF-EMT died. NIOSH was notified of this fatality on August 10, 2006 by the United States Fire Administration. NIOSH contacted the affected Fire Department to gather additional information

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 Website at

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on September 6, 2006, and on July 26, 2007 to initiate the investigation. On August 13, 2007, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Nevada to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Deputy Fire Chief
- Fire Department Occupational Health Nurse
- International Association of Fire Fighters (IAFF) Local representative
- Crew members
- FF-EMT's spouse

NIOSH personnel reviewed the following documents:

- Fire Department policies and operating guidelines
- Fire Department training records
- Fire Department annual report for 2006
- Fire Department incident report
- Emergency medical service (ambulance) incident report
- Fire Department physical examination protocols
- Fire Department medical records
- Emergency Department record
- Death certificate
- Autopsy record
- Primary care provider medical records

RESULTS OF INVESTIGATION

Incident. On August 8, 2006, the FF-EMT reported for duty at his fire station (Station 16) at approximately 0645 hours. After shift change at 0800 hours, the FF-EMT performed station duties until approximately 0930 hours. The FF-EMT, who was assigned to Engine 16, was scheduled for EMT class that afternoon and wanted to perform physical fitness training prior to the class. At approximately 0940 hours, the FF-EMT began walking on the treadmill. He elevated the treadmill to 4 degrees of elevation and performed a warm-up at approximately 4 miles per hour for 15 minutes, then accelerated the treadmill to 6 miles per hour. After walking/jogging for approximately 5 minutes at this speed, the FF-EMT suddenly collapsed. Crew members heard the noise and found the FF-EMT lying on the treadmill (0955 hours).

Crew members moved the FF-EMT off the treadmill and assessed him, finding him unresponsive, not breathing, and without a pulse. Dispatch was notified and a rescue unit (R8) was dispatched. CPR (chest compressions and assisted ventilations provided with a bag-valve-mask) was begun. An intravenous (IV) line was placed as a cardiac monitor was attached, revealing ventricular fibrillation (a heart rhythm incompatible with life). The FF-EMT was defibrillated (shocked) three times; cardiac resuscitation medications were administered via IV, with no positive change in his heart rhythm. R8 arrived on the scene at 1003 hours. Additional advanced life support measures were performed,



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including intubation (breathing tube inserted into the trachea) with a CombiTube®. Three additional defibrillation attempts were performed without improvement in the FF-EMT's status. The FF-EMT was placed onto a stretcher and into R8, which departed the scene at 1011 hours.

En route, advanced life support procedures and CPR continued. Cardiac pacing was attempted unsuccessfully. R8 arrived at the hospital at 1015 hours. Inside the Emergency Department, CPR and advanced life support measures continued until 1033 hours, when the FF-EMT was pronounced dead by the attending physician.

Medical Findings. The death certificate and autopsy completed by the County Medical Examiner on August 9, 2006, listed "atherosclerotic cardiovascular disease" as the cause of death. Pertinent findings from the autopsy included:

- Cardiomegaly (heart weighed 620 grams [g]; normal weight is <400 g) [Siegel 1997]
- Atherosclerotic coronary artery disease
- Complete (100%) focal occlusion of the circumflex coronary artery
- Moderate (75%) focal narrowing of the left anterior descending coronary artery
- Moderate (75%) focal narrowing of the right coronary artery
- No evidence of thrombus (blood clot)
- Replacement fibrosis of the posterior left ventricle consistent with a remote (old) myocardial infarction (heart attack)
- Normal cardiac valves

- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Negative drug and alcohol tests

The FF-EMT was 71" tall and weighed 235 pounds, giving him a body mass index (BMI) of 32.77. A BMI >30.0 kilograms per meters squared (kg/m^2) is considered obese [National Heart, Lung, and Blood Institute 2005]. The FF-EMT was diagnosed in 1991 with high blood cholesterol that was treated with a low fat diet. On March 14, 2006, he was prescribed a lipid-lowering medication (Vytorin®).

The FF-EMT had annual Fire Department exercise stress tests since 1997 (age 40). The tests were conducted using the Bruce protocol [Sport Fitness Advisor 2007] and he typically reached at least Stage IV (exercised for > 12 minutes and > 13 METs), without ischemic EKG changes. He did, however, have some early repolarization changes, a rare arrhythmia, but these changes were considered minor and no further work-up was recommended. The FF-EMT's last Fire Department medical evaluation was in February 2006, when his 6th treadmill stress test was performed. He exercised for 13 minutes, 44 seconds (15.1 metabolic equivalents [METS]), reaching a peak heart rate of 152 beats per minute (88% of his maximum). No ischemic changes were seen during exercise. However, there was one episode of bigeminy (two consecutive premature ventricular contractions) during the test.

According to his family and crew members, the FF-EMT had no complaints of chest pains, unusual shortness of breath on exertion, or any other heart-related illness.



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DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department consisted of 735 uniformed personnel and served a population of 1,747,000 residents in a geographic area of 8,000 square miles. There are 25 fire stations. Fire fighters work the following schedule: 24-hours on-duty, 48-hours off-duty, from 0800 hours to 0800 hours.

In 2006, the Fire Department responded to 114,214 calls: 82,030 rescue emergency medical calls, 697 residential structure fires, 168 other structure fires, 882 vehicle fires, 484 brush/grass fires, 174 rubbish fires, 406 other fires, 3,647 mutual aid calls, 2,673 false alarms, 564 hazardous materials calls, 464 hazardous condition calls, and 22,025 other calls. Station 16 (where the FF-EMT worked) responded to 8,379 calls in 2006. The FF-EMT was assigned to Engine 16, which responded to 2,625 of the aforementioned calls in 2006, averaging 7 calls per day. On the day prior to the incident, the FF-EMT worked at home performing household tasks.

Employment and Training. The Fire Department requires all new fire fighter applicants to pass a written test, a candidate physical ability test (CPAT) [IAFF/IAFC 1999], an interview, a psychological examination, and a review with the Fire Chief prior to being hired. Newly-hired fire fighters must then pass a physical examination (described below) and a drug screen prior to being sent to the 16-week fire fighter training course at the County Fire Academy to become certified as a Fire Fighter I. The FF-EMT was certified as a Fire Fighter II, Fire Officer I, Fire Service Instructor, EMT-Intermediate, HazMat Technician, and had 17 years of firefighting experience.

Pre-placement Medical Evaluation. The Fire Department requires a pre-placement medical evaluation for all new hires, regardless of age. Components of this evaluation include the following:

- A complete medical history
- Physical examination (including vital signs)
- Complete blood count with lipid panel
- Pulmonary function test (PFT)
- Audiogram
- Vision screen
- Urinalysis
- Urine drug screen
- Resting electrocardiogram (EKG)
- Chest x-ray (baseline)
- Mantoux tuberculosis (TB) skin test
- Hepatitis B vaccinations
- Hepatitis C screen (baseline)
- Vaccines or boosters, if needed, for the following:
 - Tetanus/diphtheria
 - Measles, mumps, rubella (MMR)
 - Polio
 - Varicella
 - Influenza

These evaluations are performed by a Fire Department physician, who makes a determination regarding medical clearance for firefighting duties.

Periodic Medical Evaluations. Periodic (annual) medical evaluations are required by the Fire Department for all fire fighters. Components of this evaluation include:

- A complete medical history
- Physical examination
- Complete blood count with lipid and hepatitis panel



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- Resting EKG with treadmill stress test if over age 45
- Chest x-ray (biannual)
- PFT
- Audiogram
- Vision screen

These evaluations are performed by the Fire Department physician, who makes the final determination regarding medical clearance for firefighting duties.

Annual SCBA medical clearance is required. If an employee is injured at work, the employee must be evaluated by the Worker's Compensation physician, who forwards the results to the Fire Department Risk Management Office, who makes the final determination regarding "return to work."

If the employee is off duty for 3 or more shifts due to non-occupational illness/injury, the employee must be evaluated by his/her primary care physician, who completes a medical return-to-work form. The employee then provides this form to his/her immediate supervisor and then to the Operations Chief, who makes the final determination regarding "return to work."

Health and Wellness Programs. Exercise (strength and aerobic) equipment is located in the fire stations. The Fire Department maintains a "voluntary," on-duty wellness/fitness program. Health maintenance programs are also available from the County. An annual physical ability test is not required.

DISCUSSION

In the United States, CAD (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2005]. Risk factors for its development include age over 45, male gender, family history of CAD, high blood pressure, high blood cholesterol, obesity, physical inactivity, and diabetes [AHA 1998; Jackson et al. 2001]. The FF-EMT had four of these risk factors (age over 45, male gender, high blood cholesterol, and mild obesity), and had CAD on autopsy.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2005]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion [Shah 1997]. 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 [Fuster et al. 1992]. This sudden blockage is primarily due to blood clots (thromboses) forming on top of atherosclerotic plaques. On autopsy, the FF-EMT had evidence of a remote (old) heart attack (fibrosis) in the posterior portion of his heart and 100% occlusion (but no recent thrombus) in the coronary artery supplying this region of the heart (circumflex artery).

Establishing the occurrence of a recent (acute) heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes, or coronary artery thrombus. In the FF-EMT's case, he never regained a heart rhythm on



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which an EKG could reveal characteristic changes, cardiac enzyme testing was not performed (but the enzymes do not become positive for at least 4 hours post-heart attack) [AHA 2006], and no thrombus was found at autopsy. However, not all heart attacks have an associated coronary artery thrombus. Given the autopsy findings of an old heart attack, it is entirely possible the FF-EMT suffered another heart attack, but this cannot be confirmed. It is not clear why the FF-EMT's exercise stress tests from 1997-2006 did not identify his prior heart attack or show ischemic changes.

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks [Willich et al. 1993; Mittleman et al. 1993; Siscovick et al. 1984; Tofler et al. 1992]. The FF-EMT had completed about 20 minutes of brisk walking on the treadmill. This activity expended about 7-8 METs, which is considered moderate to heavy physical activity [American Industrial Hygiene Association Journal 1971; Ainsworth 2003; Ainsworth et al. 1993]. Heart attacks in fire fighters have been associated with alarm response, fire suppression, and heavy exertion during training (including physical fitness training) [Kales 2003, Kales 2007, NIOSH 2007]. Given the FF-EMT's underlying CAD, the physical stress of performing physical fitness training probably triggered a heart attack, his subsequent cardiac arrest, and his sudden cardiac death.

As mentioned earlier, on autopsy, the FF-EMT had evidence of atherosclerotic disease in his coronary arteries with total occlusion of the circumflex coronary artery and evidence of an “old” (several months to years previous) heart attack in the region supplied by this artery. The

FF-EMT did not report any episodes of chest pain (angina) during physical activity (on or off-the-job), nor during this episode. This lack of chest pain, however, does not rule out a heart attack, because in up to 20% of individuals, the first evidence of CAD may be myocardial infarction or sudden death [Libby 2005; Thaulow et al. 1993].

Cardiomegaly. On autopsy, the FF-EMT had an enlarged heart (cardiomegaly). This condition was probably related to chronic ischemic heart disease due to his underlying coronary artery disease. However, without microscopic examination of his heart tissue, some type of cardiac myopathy cannot be ruled out.

RECOMMENDATIONS

The NIOSH investigator offers the following recommendations to address general safety and health issues. It is unlikely these recommendations would have prevented the FF-EMT's sudden cardiac death.

Recommendation #1: Develop a structured comprehensive wellness/fitness program to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

NFPA 1500 requires that a Fire Department have a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being [NFPA 2007a]. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days [Maniscalco et al. 1999; Stein et al. 2000; Aldana 2001]. Health promotion programs in the fire service have been shown to reduce



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CAD risk factors and improve fitness levels, with mandatory programs showing the most benefit [Blevins et al. 2006; Dempsey et al. 2002; Womack et al. 2005]. One mandatory program was able to show a cost savings of \$68,741 due to reduced absenteeism [Stevens et al. 2002]. A similar cost savings has been reported by the wellness program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs [City Auditor, City of Phoenix, AZ 1997]. Guidance for implementation and components of a comprehensive wellness/fitness program are found in NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters* [NFPA 2000], and in the IAFF/IAFC's *Fire Service Joint Labor Management Wellness/Fitness Initiative* [IAFF, IAFC 2000].

Recommendation #2: Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural firefighting.

NFPA 1500 requires Fire Department members who engage in emergency operations to be annually evaluated and certified by the Fire Department as having met the physical performance requirements identified in paragraph 8-2.1 of the standard [NFPA 2007a].

Recommendation #3: Eliminate or reduce the frequency of periodic chest x-rays in asymptomatic fire fighters, unless clinically indicated.

According to NFPA 1582, “chest x-rays shall include an initial baseline and shall be repeated every 5 years or as medically indicated” [NFPA 2007b]. Chest x-rays are currently being

conducted every other year during the FD’s annual medical evaluation. Conducting chest x-rays this frequently exposes members to unnecessary radiation and represent an unnecessary expense for the FD. In addition, these x-rays are not recommended by the OSHA Hazmat Standard, unless clinically indicated (e.g., respiratory symptoms) [CFR¹ 2002, NIOSH 1985].

¹Code of Federal Regulations. See CFR in references.

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