



Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

August 24, 2005

Captain Suffers an Acute Aortic Dissection After Responding to Two Alarms and Subsequently Dies Due to Hemopericardium – Pennsylvania

SUMMARY

On January 21, 2004, a 35-year-old male volunteer Captain responded to two alarms: a motor vehicle crash (MVC) with an injury, and a reported house fire that turned out to be a false alarm. Returning to the fire station after the false alarm, he complained of not feeling well and went home. After being home about 15 minutes, he collapsed. The Captain was transported to the local hospital and later flown to a regional hospital for diagnostic testing. Despite having a cardiac catheterization with coronary angiography, and a chest computed tomography (CT) scan, his aortic dissection went undiagnosed. He was treated for bilateral pneumonia but his condition continued to deteriorate. Despite cardiopulmonary resuscitation (CPR) and advanced life support (ALS), the Captain was pronounced dead approximately 20 hours after his initial complaint. The autopsy revealed the cause of death to be “hemopericardium” due to an “aortic rupture” and “aortic dissection.”

It is unlikely the following recommendations could have prevented the Captain’s death. Nonetheless, the NIOSH investigators offer these recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters.

- ***Provide mandatory pre-placement and annual medical evaluations to ALL fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments to determine their medical ability to perform duties without presenting a***

significant risk to the safety and health of themselves or others.

- ***Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting.***
- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***
- ***Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582, Standard on Comprehensive Occupational Medicine Program for Fire Departments.***

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 www.cdc.gov/niosh/firehome.html or call toll free 1-800-35-NIOSH



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- ***Provide fire fighters with medical clearance to wear self-contained breathing apparatus (SCBA).***

INTRODUCTION & METHODS

On January 22, 2004, a 35-year-old male Captain died after suffering a dissection of his aortic artery. On January 28, 2004, NIOSH contacted the affected fire department (FD) to initiate the investigation. On June 13, 2005 an Occupational Health Nurse Practitioner and a Public Health intern from the NIOSH Fire Fighter Fatality Investigation Team traveled to Pennsylvania to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed the following people:

- Fire Chief
- Captain's wife
- Captain's brother

During the site visit NIOSH personnel reviewed the following documents:

- FD policies and operating guidelines
- FD training records
- FD annual report for 2004
- Ambulance response report
- Hospital records
- Past medical records of the Captain from the primary care physician (PCP)
- Autopsy results
- Death certificate

INVESTIGATIVE RESULTS

Incident. On January 21, 2004, at approximately 1500 hours, the Captain was doing maintenance on the fire station's furnace. At approximately

1745 hours the Captain responded with other members of the FD to a MVC with injuries. During the response, the Captain ran equipment and conducted personnel accountability checks. Once the victim was removed from the vehicle, the Captain returned to the station and resumed the furnace work (1805 hours). At approximately 1954 hours the station was dispatched to a reported house fire. The Captain drove the engine to the address and assumed incident command of outside operations. No fire could be located and the Captain cancelled incoming mutual aid companies. All units were released and the Captain returned to the station at approximately 2048 hours. At the station, he complained of not feeling well and was relieved from completing the FD's incident report.

The Captain drove his personal vehicle home. At 2100 hours, the station received a call from the Captain's wife stating that he was complaining of fullness in his throat when he suddenly collapsed. A paramedic and two other fire fighters from the station responded. Upon arrival, the Captain was conscious, complaining of pain radiating from his neck to his groin. They administered basic life support until the ambulance, staffed with two paramedics, arrived. The ambulance paramedics found the Captain cyanotic, having difficulty breathing, and complaining of throat pain radiating to his groin that did not change with movement. Vital signs were taken showing a pulse of 110 beats per minute (bpm), 32 respirations per minute, and blood pressure 210/140 millimeters of mercury (mmHg). Paramedics administered ALS (oxygen applied via a non-rebreather mask and nitroglycerin administered) and applied an electrocardiogram that indicated a normal sinus rhythm (NSR). He was placed into the ambulance and transported to a local hospital's emergency department (ED).



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The Captain arrived at the local ED at 2137 hours. Initial impression in the ED was chest pain related to myocardial infarction (MI), otherwise known as a heart attack. An electrocardiogram (EKG) showed NSR with evidence of an old MI. Cardiac enzymes were normal. A chest x-ray was administered (lungs clear, no effusion, edema, or pneumonia, and with a normal heart size) but the interpretation was hindered by the Captain's body mass (height 71 inches and weight 375 pounds). Vital signs at 2200 hours were pulse 91 bpm, 14 respirations per minute, and a blood pressure of 133/59 mmHg. At 1100 the Captain complained of more severe pain despite being administered intravenous (IV) pain medications. At that time vital signs were pulse 82 bpm, 24 respirations per minute, and blood pressure 118/52 mmHg. A re-evaluation led the ED to suggest possible pulmonary embolism or aortic dissection. Recognizing that an emergent intervention was necessary, a transfer was arranged using helicopter transport to a larger regional hospital. The helicopter arrived at the local hospital at 2335 hours, departed at 2350 hours, and arrived at the regional hospital at 2359 hours.

At the regional hospital the Captain was immediately taken into the cardiac catheterization lab. Coronary angiography was remarkable for the lack of any significant coronary artery disease, a normal ejection fraction and a normal aortic root caliber without evidence of dissection. Because the Captain was hypoxic on room air, he was subsequently admitted to the cardiac intensive care unit where a chest x-ray and CT scan were performed. Once again, due to his body size, the quality of the study was reduced, but no evidence of a pulmonary embolus or pulmonary effusion was found. However, posterior portions of both lower lobes showed an opacification that was diagnosed as probable pneumonia. Also, a small

pericardial effusion was noted during the scan and a widening upper mediastinum was noticed on the chest x-ray. The Captain was transferred to the medical intensive care unit and IV antibiotics were administered. He remained alert and oriented until approximately 1645 hours.

At approximately 1645 hours the Captain suddenly became ashen, lost consciousness, and appeared to have a seizure. His heart rate was tachycardiac at 120 bpm. While waiting to get a blood pressure reading, the Captain awoke briefly to complain of further abdominal pain. He again lost consciousness and ALS measures were begun. He was intubated and a large caliber catheter was inserted into the femoral vein into which 3 liters of saline were administered under pressure. No pulse or blood pressure could be identified, and the Captain was given various ALS medications that failed to convert his heart rhythm to one that would support life. The Captain's heart rhythm degenerated into asystole (no heart beat) at which time resuscitation efforts ceased. He was pronounced dead at 1730 hours on January 22, 2004.

Medical Findings. The death certificate, completed by the attending physician, listed "bilateral pneumonia" as the immediate cause of death. The autopsy was performed by a pathologist. Significant findings were as follows:

- Hemopericardium with 575 milliliters (mL) of primarily unclotted blood in pericardium
- Rupture of the intra-pericardial portion of the ascending thoracic aorta
- Thoracoabdominal aortic dissection extending from the ascending aorta to the distal abdominal aorta (4 cm above the iliac bifurcation)
- History of hypertension



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- Cardiomegaly, heart weighing 560 grams (normal < 400 grams)
- Moderate cardiac left ventricular hypertrophy
- Minimal coronary artery disease (25% stenosis of the left anterior descending and right coronary arteries)
- No evidence of infection in his left or right lung fields (pneumonia), although there were bilateral serosanguinous pleural effusions (200 mL on the left, 150 mL on the right)
 - Morbid obesity, with a body mass index of 51.9 kilograms/meters². A BMI over 30 kg/m² is considered obese.¹

The fire fighter had a history of hypertension since at least 1998. His hypertension was under control by prescription medication with variable compliance. His most recent blood pressure (January 9, 2004) was 150/100 mmHg. According to family and fire department personnel, the Captain never exercised. He had expressed no signs or symptoms of chest pain or any other discomfort to his wife, co-workers, or health care providers prior to this incident. He had no family history of aortic dissection or aneurysm.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the FD was an all volunteer department consisting of 34 fire fighters. Its one fire station served a population of 5,000 in a geographic area of 10 square miles.

In 2004, the FD responded to 400 calls: 26 fires, 199 rescue and medical calls, 8 hazardous condition calls, 110 false alarm/good intent calls, 31 service calls, and 26 other calls and incidents.

Training. The FD requires all new volunteer fire fighter applicants to complete an application and an interview with the chief. They are then voted on by the membership. They must attend a fundamentals of fire course at which they take a physical agility test. This class is taught either during fire week at the state fire academy or at any of the regional fire schools. Once they have successfully passed this course new applicants are allowed to perform interior fire attack. The Captain was a certified state Fire Fighter I, EMT, Hazmat, and Driver/Operator and had 18 years of fire fighting experience.

Pre-placement Medical Evaluations. The FD does not require a pre-placement medical evaluation.

Periodic Medical Evaluations. The FD does not require periodic medical evaluations. Employees injured at work are evaluated by and must be cleared for return to work by a township contracted physician. As described earlier, the Captain's last medical examination occurred 12 days before he died.

Fitness/Wellness Programs. The fire station has an aerobic fitness program on site, but no strength training programs. Participation in fitness training is voluntary. No wellness/health maintenance programs (smoking cessation, weight control, high blood pressure, diabetes, and cholesterol) are offered by this department. The FD, however, is considering implementing these health maintenance programs.

DISCUSSION

Aortic Dissection and the Pathophysiology of Sudden Death. Aortic dissection, a splitting of the aortic wall, is caused by a tear of the interior



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lining of the aorta (intima).^{2,4} The initiating event is either a primary intimal tear with secondary dissection into the middle or muscular coat of the artery (media) or a medial hemorrhage that dissects into the intima. In this case, the autopsy confirmed the presence of an intimal tear. The pulsatile aortic flow then travels between the inner and outer surfaces creating a false lumen.^{2,4} The Captain's case was complicated by the retrograde flow back into the intra-pericardial portion of the ascending thoracic aorta. This allowed blood to leak into the pericardium resulting in cardiac tamponade. Cardiac tamponade applies pressure from the "outside" of the heart, decreasing cardiac output. Without intervention, cardiac tamponade due to aortic dissection typically leads to death.

Hypertension is a predisposing factor for aortic dissection. Uncontrolled hypertension can lead to a weakening of the aortic wall. The weakened wall and the increased pressure strain the aorta which, over time, can lead to a tear in the wall.^{2,4} The Captain was diagnosed with hypertension in 1998 and only had sporadic control since that time.

The peak incidence of aortic dissection is in the sixth and seventh decades of life. Men are more affected than women by a ratio of 2:1. The presentations of aortic dissection and its variants are the consequences of intimal tear, dissecting hematoma, occlusion of involved arteries, and compression of adjacent tissues. Acute aortic dissection typically presents with the sudden onset of pain, which is often described as very severe chest pain that radiates to the back and is frequently associated with sweating (diaphoresis).^{2,4,6} Other symptoms include syncope, dyspnea, and weakness.²

Left ventricular hypertrophy. The Captain was found on autopsy to have had moderate left ventricular hypertrophy. Hypertrophy of the heart's left ventricle is a relatively common finding among individuals with long-standing high blood pressure (hypertension), a heart valve problem, or cardiac ischemia (reduced blood supply to the heart muscle). Cardiac hypertrophy is one form of hypertrophic cardiomyopathy (HCM). The diagnosis of HCM, from the pathologist, was based on his enlarged heart (560 grams; normal is < 400 grams) and thickened left heart ventricles (1.6 centimeters; normal is 0.76-0.88 centimeters).

Approximately one-half of HCM cases are transmitted genetically, typically in an autosomal dominant trait without disease loci on at least eight different chromosomes. The cause of HCM in the other patients is unknown. Because the Captain had siblings and children, medical screening of relatives is warranted.

RECOMMENDATIONS

It is unlikely the following recommendations could have prevented the Captain's death. Nonetheless, the NIOSH investigators offer these recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters.

Recommendation #1: Provide mandatory pre-placement and annual medical evaluations to ALL fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments⁷ to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.



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Guidance regarding the content and frequency of pre-placement and periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582 and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.⁸ The Department is not legally required to follow any of these standards.

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)** provide permanent alternate duty positions or other supportive and/or compensated alternatives if the fire fighter is not medically qualified to return to active fire fighting duties.

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

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Programs* requires fire department members who engage in emergency operations to be annually evaluated and certified by the fire department as meeting the physical performance requirements identified in paragraph 8-2.1.⁹

Recommendation #3: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.

The IAFF and the IAFC 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 and a video detailing elements of such a program.⁸ Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.^{10,11} 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 disability pension costs.¹²

In January 2004, the National Volunteer Fire Council and US Fire Administration published a comprehensive manual, *Health and Wellness Guide for the Volunteer Fire Service*.¹³ The guide provides suggestions for program initiation and features. This guide is useful for not only volunteer fire departments, but also small combination fire departments that could benefit from some type of fitness and wellness program. The FD should implement this recommendation to ensure Coronary Artery Disease (CAD) risk factors are reduced and cardiovascular capacity is increased.

Recommendation #4: Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582, Standard on Comprehensive Occupational Medicine Program for Fire Departments.

Physicians who provide input regarding medical clearance for fire fighting duties should be



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knowledgeable about the physical demands of fire fighting and that fire fighters frequently respond to incidents in environments that are immediately dangerous to life and health. They should also be familiar with a FF's personal protective equipment and the consensus guidelines published by NFPA 1582, *Standard on Comprehensive Occupational Medicine Program for Fire Departments*. To ensure physicians are aware of these guidelines, we recommend that the FD, or the FF, provide the personal physicians with a copy of NFPA 1582.

We also recommend the FD retain a "fire department physician" to review all medical clearances, and not necessarily "rubber stamp" the opinions of specialists or other treating physicians regarding return to work. This decision requires knowledge not only of the medical condition, but also of the fire fighter's job duties. Personal physicians may not be familiar with an employee's job duties, or with guidance documents such as NFPA 1582. In addition, they may consider themselves patient advocates and dismiss the potential public health impact of public safety officials who may be suddenly incapacitated. Therefore, we recommend that a "FD physician" who has the final decision regarding medical clearance review all return-to-work clearances.

Recommendation #5: Provide fire fighters with clearance to wear self-contained breathing apparatus (SCBA) as part of the Fire Department's medical evaluation program.

OSHA's Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection.¹⁴ These clearance evaluations are required for private industry employees and public employees in states operating OSHA-ap-

proved State plans. Pennsylvania does not operate an OSHA-approved state plan, therefore, public sector employers are not required to comply with OSHA standards. Nonetheless, we recommend following this standard to ensure fire fighters are medically cleared annually to wear SCBA.

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