



NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

August 31, 2004

Fire Fighter-Paramedic Dies After Performing Physical Fitness Training—Florida

SUMMARY

On January 27, 2004, a 35-year-old male Fire Fighter-Paramedic (FF-P) had just finished jogging around a training building when he suddenly collapsed. Paramedic instructors and fellow students immediately began cardiopulmonary resuscitation (CPR) and advanced life support (ALS). An ambulance was summoned and ambulance personnel continued ALS during transport to the hospital. After 27 minutes of treatment in the hospital's emergency department, the FF-P was pronounced dead and resuscitation efforts were discontinued. The death certificate and the autopsy report, completed by the County Medical Examiner, listed "aortic valve stenosis" as the immediate cause of death.

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 individuals at higher risk; and 3) encouraging increased individual physical capacity. The following issues are relevant to this fire department:

- *Conduct EST according to the ACC/AHA protocols*

Although unrelated to this fatality, the fire department should consider these additional recommendations based on safety and economic considerations:

- *Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity*

- *Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBA)*
- *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*
- *Discontinue the routine use of annual chest x-rays unless medically indicated*
- *Discontinue the routine use of annual electrocardiograms (EKG) unless medically indicated*
- *Provide adequate fire fighter staffing to ensure safe operating conditions*

INTRODUCTION & METHODS

On January 27, 2004, a 35-year-old male FF-P suddenly collapsed after jogging around a training building. Despite CPR and ALS at the scene, during

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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transport, and at the hospital, the FF-P died. NIOSH was notified of this fatality on February 12, 2004, by the United States Fire Administration. On February 13, 2004, NIOSH contacted the affected Fire Department to obtain additional information, and on March 15, 2004 to initiate the investigation. On March 29, 2004, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Florida to conduct an onsite investigation of the incident.

During the investigation NIOSH personnel met with and/or interviewed:

- Fire Chief
- Training Officer
- Crew members involved in this incident
- The FF-P's family

During the site-visit NIOSH personnel reviewed:

- FD policies and operating guidelines
- FD training records
- The FD annual report for 2003
- The victim's personnel record maintained at the FD
- The incident summary
- The police report
- The ambulance report
- The hospital records
- Death certificate
- Autopsy report
- Past medical records of the deceased

INVESTIGATIVE RESULTS

Incident Response. On January 27, 2004, the FF-P left his fire station after his 24-hour shift at approximately 0700 hours and drove to the local college where he was enrolled in the State "Fire Fighter Minimum Standards" class. The morning was spent in classroom listening to lectures. At approximately 1330 hours, the class began physical fitness training, which consisted of jogging around

the training building four times, equaling one mile. Immediately after finishing his jog, the FF-P entered the equipment room then suddenly collapsed and began having seizures. Classmates immediately went to his assistance while instructors notified 911 at 1344 hours and Rescue 35 was dispatched.

Initial assessment by classmates found the FF-P to be unresponsive, pulseless, and not breathing. CPR (chest compressions and assisted ventilations via bag-valve-mask with 100% oxygen) was begun and the FF-P was placed on a semi-automated external defibrillator (SAED), which revealed ventricular fibrillation (V.fib.). He was defibrillated but his heart rhythm reverted to pulseless electrical activity (PEA) (a heart rhythm unable to sustain life).

Rescue 35 arrived on the scene at 1347 hours and found the FF-P unresponsive, pulseless, and not breathing with CPR in progress. Intravenous access was gained and medications consistent with ALS guidelines were administered. Three attempts at intubation were unsuccessful and the FF-P was placed into the Rescue for transport to the hospital while CPR continued. Rescue 35 departed the scene at 1356 hours enroute to the hospital.

During transport, another intubation attempt was made without success. The SAED again revealed V.fib. and four defibrillation attempts were made before his heart rhythm reverted, once again, to PEA. Cardiac pacing was attempted without success and additional resuscitation medications were administered. The fifth attempt at intubation was successful with confirmation from bilateral breath sounds.

Rescue 35 arrived at the hospital emergency department (ED) at 1405 hours, approximately 25 minutes after his collapse. Inside the ED, the FF-P's heart rhythm was assessed and found to alternate



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between asystole (no heart beat) and PEA. ALS protocols were followed and CPR continued with no change in status until 1432 hours, when he was pronounced dead and resuscitation efforts were discontinued.

Medical Findings. The death certificate, completed by the County Medical Examiner, listed “aortic valve stenosis” as the immediate cause of death. Pertinent findings from the autopsy, performed by the County Medical Examiner on January 28, 2004, include the following:

- Aortic valve stenosis
 - Left ventricular hypertrophy, marked
 - Calcified aortic valve with commissure fusion
- Cardiomegaly (heart weighing 440 grams with normal less than 400 grams)¹
- Mild, patchy, interstitial fibrosis [as determined by microscopic examination]
- No evidence of thromboemboli
- No evidence of atherosclerosis

In May 2002, the FF-P underwent a physical evaluation to participate as a County HazMat Team Paramedic. The evaluation revealed a significant Grade V/VI holosystolic murmur. An exercise stress test (EST) using a “manual” protocol was conducted. This protocol consisted of exercising the subject at increasing speed (up to 4.3 miles per hour) at 0% grade. The FF-P exercised for 12 minutes 58 seconds reaching 5.8 metabolic equivalents (METs) before the test was stopped. Why the EST was stopped at this point is not clear. He did not express symptoms of fatigue or angina. His electrocardiogram did not reveal signs of ischemia or arrhythmias. He had a good blood pressure and pulse response; his pulse reaching 121 beats per minute which was 65% of his maximum heart rate. Due to his heart murmur, he was placed on medical hold and was advised to follow up with his family doctor or cardiologist.

In March 2003, the FF-P underwent a FD pre-placement medical evaluation which was remarkable for his previously identified systolic heart murmur, and an elevated low density lipoprotein (LDL) cholesterol level of 118 milligrams per deciliter (mg/dL) (normal < 100 mg/dL), but a normal total cholesterol level of 184 mg/dL, and a total cholesterol/HDL ratio of 3.35 (one-half the average risk of coronary heart disease). A low cholesterol diet was recommended and he was cleared for fire fighting duty.

In January 2004, he underwent another physical examination for State training which again revealed his systolic murmur. An EKG revealed flipped T waves in the lateral leads, a new finding from his last EKG in March, 2003. Nonetheless, the FF-P was cleared to participate in the training although a cardiology evaluation was recommended. This was the second time an evaluation recommended a cardiology follow-up, but it was never required. According to the records available to NIOSH, the FF-P never consulted with a cardiologist.

According to his family and crewmembers, the FF-P was very active, exercised regularly, and had no complaints of angina (chest pain), shortness of breath, dyspnea on exertion, or any other symptoms suggestive of a heart condition.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the combination FD was comprised of 40 uniformed personnel (12 career and 28 reserves) and served a population of 7,200 residents and a daytime population of 70,000 in a geographic area of 7 square miles. There is one fire station where fire fighters work the following tour of duty: 24 hours on-duty, 48 hours off-duty, 0700-0700 hours. Each shift of an engine or ladder company is staffed with at least

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two fire fighters; mutual aid engines from neighboring cities are staffed with three fire fighters. Structural fire response includes two engines, one ladder, and a mutual aid engine. Reserves respond and staff additional apparatus. The emergency medical service is a component of the FD.

In 2003, the FD responded to 2,589 total calls: 17 structure fires, 16 brush, grass, and wildland fires, 20 rubbish fires, 15 vehicle fires, 15 other fires, 210 false alarms, 118 hazardous condition calls, 293 service calls, 4 severe weather calls, and 1,881 rescue/emergency medical responses.

The day prior to the incident described herein, the FF-P responded to a medical call at 2208 hours. He retired for the night at approximately 2400 hours. The day of the incident, the FF-P responded to two medical calls: one at 0625 hours and one at 0651 hours, prior to leaving his fire station after his regular shift. At approximately 0700 hours, he went to his training class. During the day he attended classroom training after which he jogged around the training building four times.

Training. The FD requires all new career fire fighter applicants to submit an application, pass an interview, a criminal history check, a physical examination, and a drug screen prior to being given a conditional job offer. The newly hired fire fighter is then sent to the 450-hour State Minimum Standards training (consisting of classroom, practical, and physical fitness training) unless previously certified. Recurrent training occurs on each shift.

Reserve fire fighter applicants must submit an application, pass an interview, a background check, a drug screen, and a physical examination prior to being selected. The fire fighter is then enrolled in the FD 90-day orientation program. The fire fighter may also be sent to the State Minimum Standards training unless previously certified.

Prior to attending initial State fire fighter training, a fire fighter/candidate must pass a physical examination. Components of the pre-training evaluation for all fire fighters include:

- A complete medical history and questionnaire
- Height, weight, and vital signs
- Physical examination
- Vision test
- Hearing test
- Resting electrocardiogram, and
- Respiratory questionnaire (OSHA form)

This physical evaluation is completed by the fire fighter's private physician. The results are forwarded to the State Fire Marshal's Office, who makes the final determination for clearance to begin training.

The State requires all career fire fighter candidates to:

- Be a minimum of 18 years of age
- Be a high school graduate or equivalent
- Pass a medical evaluation prior to training
- Not use tobacco products
- Be State-certified fire fighters
- Have completed the 160 hour Firefighter I training, and
- Have completed the 200 hour Firefighter II training

The State requires career fire fighters to become certified within one year of hire. There is no mandatory State requirement for volunteer fire fighter certification. All State-certified fire fighters must remain active in a 3-year period in order to maintain status as a fire fighter. There is no State requirement for recertification. Annual re-certification is required for hazardous materials responders; while Emergency Medical Technician and Paramedic recertification is bi-annual.

The FF-P was a certified Fire Fighter I, Emergency Medical Technician-Paramedic, and had 10 months of fire fighting experience.

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Pre-placement Evaluations. The FD requires a pre-placement medical evaluation for all new hires and reserves. Components of the pre-placement 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
- Spirometry
- Resting 12-lead electrocardiogram
- Exercise stress test
- Chest x-ray
- Body fat percent test
- Functional capacity back test
- Prostate-specific antigen (PSA) test for males over age 40
- Mantoux PPD (tuberculosis) test
- Hepatitis B antibody titer
- Hepatitis B vaccination if needed
- Hepatitis C antibody test
- Human immunodeficiency virus (HIV) test
- Tetanus vaccination (if needed)

These evaluations are performed by a City-contracted medical clinic, who forwards the results to the Human Resources Department, who then makes a final decision regarding medical clearance for fire fighting duties.

Periodic Evaluations

Annual/periodic medical evaluations are required by this FD for all fire fighters. The components of the evaluation are the same as the pre-placement medical evaluation. If an employee is injured at work, he/she must be cleared for “return to work” by the City-contracted physician. If an employee is ill and away from work, he/she must be cleared for “return to

work” by the City-contracted physician. There are no annual/periodic physical ability tests required by this FD. Exercise (strength and aerobic) equipment is available in the fire stations. Health maintenance programs or fitness/wellness programs are offered. Medical clearance for SCBA use is not required.

DISCUSSION

Aortic stenosis (AS) is the narrowing of the aortic valve which decreases the outflow of blood from the heart. It is the most common cardiac valve lesion in the United States and arises from congenital disorders (e.g. bicuspid valve) or from acquired conditions (e.g. rheumatic fever, hypertension, endocarditis, connective tissue disorders, etc).^{2,3} Condition severity is determined by the valve surface area: mild (1.5-2.0 centimeters squared [cm²]), moderate (1.0-1.5 cm²), severe (< 1.0 cm²).⁴ Symptoms typically develop when the valve area shrinks to d”1 cm². The most common symptoms are: decreased exercise tolerance due to fatigue or dyspnea, exertional angina, and exertional light-headedness or syncope.^{2,5,6}

The stenotic aortic valve eventually results in a compensatory left ventricular hypertrophy (LVH) which increase the heart muscle mass (myocardial) without an increase in the ventricular chamber.)^{2,5,7} This hypertrophy increases the myocardial oxygen demand and decreases the diastolic blood flow through the coronary arteries creating an imbalance between myocardial oxygen supply and demand.²

Findings suggestive of AS include the presence of a characteristic heart murmur (as noted in all three fire service physical examinations), and EKG changes such as left ventricular hypertrophy (LVH) or non-specific T-wave changes.^{2,6,7} The diagnosis of AS is made by characteristic findings on echocardiography. Two additional tests are commonly performed for prognostic information: a gated blood pool scan to assess ventricular function, and an EST to assess

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cardiac reserve.^{2,7,8} The EST is contraindicated in symptomatic patients but can be safely performed in asymptomatic patients under close physician observation.

Medical management includes prophylactic antibiotic treatment for endocarditis, advising the patient to limit strenuous, unmonitored exercise (due to the effect of LVH on coronary blood flow). Valve replacement is indicated in patients with severe disease.^{2,5,8,9}

Disorders of the cardiac valves can adversely affect cardiac performance and place patients at risk for a cardiac emergency.^{2,7} Natural history studies show that once classic symptoms develop, average survival decreases to 5 years with the onset of angina, 3 years after cardiac syncope, and 2 years after heart failure.^{4,8} The incidence of sudden death increases from 1-2% annually among asymptomatic patients to 15-20% among symptomatic patients.^{4,7-10}

Although not noted on the EKG tracings, it appears the FF-P met the voltage criteria for LVH in tracings from 2002 and 2004, and had non-specific ST segment/T-wave changes in tracings from 2002, 2003, and 2004.¹¹ As mentioned earlier in this report, the physician performing the Hazmat medical evaluation in 2002 was concerned about the possibility of AS and placed the FF-P on “medical hold” until he followed-up with his family doctor or a cardiologist. Unfortunately, the FF-P never pursued that recommendation.

Interestingly, the 2002 Hazmat physical examination also included an EST. It is unclear why this EST was done but possibilities include: 1) as a fitness assessment for structural fire fighting, 2) as a screening procedure to identify undetected coronary artery disease, or 3) as a prognostic assessment for AS. The third possibility was unlikely because in the medical records available to NIOSH, an echocardiogram was never performed and he was

never given the diagnosis of AS. If the EST was performed for reasons #1 or #2, it was not an adequate assessment since the FF-P only exercised up to 5.8 METS. Essential job tasks of structural fire fighters need an aerobic capacity of at least 13 METS.¹² In addition, the American College of Cardiology/American Heart Association (ACC/AHA) recommends EST be conducted with increasing speed AND **grade** and terminated when symptoms appear, not an arbitrary percentage of predicted maximal heart rate.¹³ Thus, concluding that the FF-P had a normal exercise test may have been falsely reassuring and possibly resulted in him not seeking further medical evaluation.

In 2003 the FF-P had his FD medical evaluation. Despite noting the characteristic heart murmur, the FF-P was cleared for unrestricted duty. Both the 2000 and 2003 editions of NFPA 1582 considered AS to be a Category B condition; acceptable if the condition is “mild,” defined as a aortic valvular pressure gradient < 20 millimeters of Mercury (mmHg).^{12,14} As noted previously, medical records obtained by NIOSH suggested he never received an echocardiogram or any other test to measure his aortic valve pressure gradient.

Finally, in 2004, the FF-P had his last physical examination, required by the State to participate in training exercises. Although the AS murmur and some non-specific EKG changes were noted, and a cardiology evaluation was recommended, he was approved for participation because he was asymptomatic.

Although there were numerous clues which could have led to further medical evaluation, it is not clear whether an earlier diagnosis of AS would have prevented the tragic and untimely death of the FF-P. On one hand, since he was asymptomatic and probably had mild disease, he probably would have been approved for unrestricted duty. On the other

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hand, if a diagnosis of AS was made and his clinician advised restraint from stressful heavy physical exertion, it is possible his sudden cardiac death may have been prevented at this time.

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, among other things, reduce the risk of on-the-job heart attacks and sudden cardiac death 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. The Department is not legally required to follow any of these standards.

Recommendation #1: Conduct EST according to the ACC/AHA protocols.

The American College of Cardiology/American Heart Association (ACC/AHA) recommends EST be conducted with increasing speed AND grade and terminated when symptoms appear, not an arbitrary percentage of predicted maximal heart rate.¹³ Exercise testing should be supervised by an appropriately trained physician. Symptom-limited testing with the Borg scale as an aid is very important when the test is used to assess functional capacity.

The following findings did not contribute to the death of this fire fighter but were identified by NIOSH during the inspection.

Recommendation #2: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

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, namely obesity and diabetes.¹⁵ NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.¹⁶ NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, provides the minimum requirements for a health-related fitness program.¹⁷ In 1997, the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) published 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.¹⁸ The Fire Department should review these materials to identify applicable elements for their Department. Other large-city negotiated programs can also be reviewed as potential models. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.¹⁹⁻²¹ 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.²²

Recommendation #3: Provide fire fighters with medical evaluations and clearance to wear SCBA.

OSHA's Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection.²³ Such employees include fire fighters who utilize SCBA in the performance of their duties.

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These clearance evaluations are required for private industry employees and public employees in states operating OSHA-approved State plans. Florida is not a state-plan state, therefore, public sector employers are not required to comply with OSHA standards. However, we recommend voluntary compliance for safety purposes.

Recommendation #4: 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.

NFPA 1500 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 8-2.1.¹⁶

Recommendation #5: Discontinue the routine use of annual chest x-rays unless medically indicated.

According to NFPA 1582, “chest x-rays shall include an initial baseline and shall be repeated every 5 years or as medically indicated.”¹² The chest x-rays being conducted by the Fire Department expose incumbents to unnecessary radiation and represent an unnecessary expense for the Fire Department, and are not recommended by the OSHA Hazmat standard unless indicated.²⁴

Recommendation #6: Discontinue the routine use of annual electrocardiograms (EKG) unless medically indicated.

Although NFPA 1582 states, “periodic resting electrocardiograms have not been shown to be useful but can be reasonable as a member’s age increases,”¹² the stress EKG is a much better tool to identify a number of cardiac conditions. In

asymptomatic individuals with no cardiac problems, periodic resting EKGs are not indicated.²⁵ Therefore, only pre-placement EKGs are recommended unless medically indicated. The resting EKGs being conducted by the Fire Department represent an unnecessary expense for the Fire Department.

Recommendation #7: Provide adequate fire fighter staffing to ensure safe operating conditions.

Currently, the FD staffs its first-due engines and ladder with two personnel and any additional responding apparatus with two-three call personnel. Mutual aid engines respond with three personnel. NFPA 1710 requires that “on-duty personnel assigned to fire suppression shall be organized into company units and shall have appropriate apparatus and equipment assigned to such companies.”²⁶ Those companies may respond with two apparatus, depending on the seating configuration of the apparatus to ensure four personnel arrive on scene.²⁶ Personnel assigned to the initial arriving company shall have the capability to implement an initial rapid intervention crew (IRIC),²⁶ which requires four personnel (two to enter the structure and two standing by outside). NFPA 1500 recommends that “members operating in hazardous areas at emergency incidents shall operate in teams of two or more.”¹⁶ Understaffing causes those members on-scene to work harder and for longer periods of time. Additionally, it requires the use of extra fire companies in order to meet the demand for manpower. Engine and Ladder Companies should be staffed with four personnel at a minimum.

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INVESTIGATOR INFORMATION

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