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Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation *December 30, 2005*

Airport Fire Fighter Suffers Sudden Cardiac Death While On Duty – South Carolina

SUMMARY

On August 16, 2004, a 23-year-old male military Aircraft Fire Fighter (AFF) was ending a watch at the standby position on the airfield. The standby position, a staging area adjacent to the runway, is staffed by AFFs during flight operations. At approximately 2050 hours, while awaiting the arrival of his relief, the AFF collapsed. Crew members started cardiopulmonary resuscitation (CPR), administered oxygen via a bag valve mask, and alerted dispatch of a medical emergency. Fire fighters from the base's structural fire department (civil servants) arrived 18 minutes later and attached an automatic external defibrillator (AED). Several shocks were administered without a change in the AFF's condition. Paramedics from the county emergency medical service (EMS) arrived at 2126 hours. They inserted an airway management device, established an intravenous line (IV), and administered ALS medications. The AED monitored the AFF, and CPR continued. The AFF was transported to the local hospital emergency department (ED) by ground ambulance. Despite CPR and advanced life support (ALS), he was pronounced dead at approximately 2210 hours. The autopsy revealed the cause of death to be "acute myocardial ischemia secondary to a cardiac arrhythmia of unknown etiology." Myocardial bridging (MB) and findings consistent with hypertrophic cardiomyopathy (HCM) were also found during his autopsy. The NIOSH investigator concluded that the physical stress of responding to the AFF staging area, and the physical exertion the AFF performed there, may have triggered his sudden cardiac death (SCD).

It is unlikely the following recommendation could have prevented this AFF's death. Nonetheless, the NIOSH investigator offers this recommendation to reduce the risk of sudden cardiac arrest among AFF and other fire fighters.

- ***Provide mandatory annual medical evaluations to ALL fire fighters consistent with National Fire Protection Association (NFPA) 1582,* Standard on Comprehensive Occupational Medical Program for Fire Departments, 2003 edition *to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***

INTRODUCTION & METHODS

On August 16, 2004, a 23-year-old male career AFF collapsed prior to ending a tour at the airfield standby position. Despite ALS treatment at the scene, en route, and at the hospital's ED, the AFF died. NIOSH was notified of this fatality on January 4, 2005, by the United States Fire Administration. NIOSH contacted the affected Fire Department (FD) on January 10, 2005, to obtain further information. On July 11, 2005, an Occupational Health Nurse Practitioner from the NIOSH Fire Fighter Fatality Investigation Team traveled to South Carolina to conduct an investigation of the incident.

During the investigation NIOSH personnel met and/or interviewed the following people:

- Fire Chief
- Crew members
- AFF's father
- Medical clinic personnel who conducted the FD medical evaluations

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

www.cdc.gov/niosh/fire
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- Public affairs officer
- Command legal officer

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

- FD policies and operating guidelines
- FD training records
- FD annual report for 2004
- FD physical examination protocols
- Ambulance records
- ED records
- Autopsy report

INVESTIGATIVE RESULTS

On August 16, 2004, at 0700 hours the AFF reported for duty at the air station fire department (FD). The FD operates one station whose sole function is fire protection of the military base's airfield. Mandatory physical fitness training at 0700 hours was conducted for approximately one hour. The fitness training included aerobic and strength training, activities characterized as moderate exertion. The morning and afternoon were spent checking the apparatus and firefighting gear, performing normal station duties, and engaging in directed study. The shift was marked by the normal deployment of vehicles to the runway standby position ("hot spot"), and one bunker drill in the morning lasting approximately 95 seconds. Deployments to the runway standby position are non-drill exercises in which apparatus is moved to positions near the runway to allow for quick access to aircraft accidents. Staffing usually consists of four crew members, with rotations among FD personnel at least every 2 hours, depending on the length of training operations. At 1920 hours the AFF and three other crew members deployed to the "hot spot" for their tour. The runway was in use for aircraft training exercises, and at about 2000 hours the crew began tossing around a volleyball between aircraft landings. They stopped after about 50 minutes because their relief was soon to arrive.

At about 2050 hours, while cooling down, the AFF collapsed in a manner that led his crew members to believe that he was joking. About 5 minutes later the crew splashed water on the AFF's head in an attempt to get him to climb into the apparatus for departure. When that failed to elicit a response, crew members rolled the AFF over and checked for pulse and respirations. Upon finding none, they began CPR and called dispatch at 2105 hours for an ambulance. Crewmembers then administered oxygen via a bag valve mask and continued CPR until the base's structural fire fighting department arrived at 2108 hours. The structural fire fighters found the AFF moist and clammy with no pulse or respirations. They continued CPR while attaching the AFF to an automatic external defibrillator (AED). The AED administered one defibrillation (shock) resulting in a weak pulse for a short time. Further analysis by the AED resulted in two more shocks, but subsequent analysis was disrupted by vibrations from passing aircraft. At this time the FD requested airfield traffic to be stopped, but the request was not acted upon. The FD also requested that the airfield's search and rescue helicopter transport the victim to the ED. While waiting for the helicopter to arrive, the patient was suctioned and CPR continued. Further use of the AED was unsuccessful due to flying aircraft noise and vibrations.

At approximately 2126 hours, the county ambulance with paramedics and personnel from the base's search and rescue helicopter arrived simultaneously. The ambulance had paramedic responders and air transport did not, so the victim was transported to the local hospital's ED by ambulance. The ambulance paramedics placed a laryngeal mask airway in the victim's pharynx and verified correct placement with bilateral breath sounds, then established an IV. IV medications were administered per ALS protocol. He was loaded into the ambulance, which departed for the ED at approximately 2139 hours.

En route to the ED the AFF had no heart beat (asystole). The paramedics inserted an external pacemaker that successfully captured the rhythm and paced his heart rate, but no pulse was present. A pulse oximeter reported oxygen saturation at 82% (normal 94%-98%). Just prior to arrival at the ED, his heart rhythm changed to ventricular fibrillation (a heart rhythm incompatible with life), and three stacked shocks were delivered. The AFF's heart rhythm re-

turned to asystole, and CPR with pacing continued. At 2150 hours (1 hour since he collapsed), the AFF arrived at the ED. The ED staff found that the "laryngeal mask airway was placed sideways and did not appear to be helping with the gas exchange." It was immediately removed and an endotracheal tube was placed with confirmation of correct placement by: 1) a five point auscultation and 2) a technological test using an end tidal CO_2 monitor. An internal jugular IV was placed and cardiac pacing was continued with a transvenous pacemaker. Multiple rounds of ALS medications were administered, while CPR was maintained, with no return of cardiac activity. After 25 minutes of CPR and ALS in the ED, the AFF was pronounced dead at 2215 hours, and resuscitation efforts were stopped.

Medical Findings. The autopsy, completed by a forensic pathologist, listed the probable cause of death as "acute myocardial ischemia" secondary to a cardiac arrhythmia of unknown etiology. Significant findings from the autopsy as follows:

- Enlarged heart (cardiomegaly) weighing 460 grams (normal < 400 grams)
  - Left ventricular hypertrophy (wall thickness 1.3 centimeters [cm] [normal 0.6 cm-1.1 cm])
  - Interventricular septum hypertrophy (wall thickness 1.5 cm [normal 0.6 cm-1.1 cm])
- Right coronary artery bridging
- Right ventricle mildly dilated
- Microscopic findings
  - Histological signs of ischemia
  - Scattered myocytes indicative of hypertrophy

Although the AFF had three physical examinations conducted by the nearby naval health clinic, at the time of this report no documented medical information could be found. According to his father, the AFF had no history of heart disease or risk factors for coronary artery disease. At autopsy, the AFF weighed 173 pounds and measured 6'1" tall giving a normal body mass index of 22.8 kilograms/meter^2. As a member of the armed forces, he was required to exercise regularly. He had not complained of any heart symptoms days or weeks preceding his untimely death.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this FD consisted of 75 uniformed personnel serving an airfield, Marine Corp Category II. There is one fire station. Fire fighters work the following schedule: 24 hours on-duty, 24 hours off-duty for three shifts, then three days off. Shifts change at 0700 hours. In 2004, the Department responded to 112 emergency calls.

Training. Fire fighters are recruited to fill positions within the fire service. A pre-employment/pre-placement medical evaluation is required for all fire fighters. A pre-employment/pre-placement physical ability test is performed after the medical evaluation. After basic military training, the newly recruited fire fighter attends the Fire Protection Specialist Course at Good Fellow Air Force Base, Texas. The course lasts 68 training days. Upon graduation the fire fighter earns the following certifications: American Heart Association CPR, Department of Defense (DOD) First Responder, DOD Fire Fighter II, DOD Hazardous Material (Hazmat) Operations Level and DOD Airport Fire Fighter. The recruits are then assigned to various military fire/air station departments throughout the world.

Recurrent training occurs daily on each shift. The AFF had the above certifications in addition to driver/operator and public safety telecommunications. He had 21 months of fire fighting experience.

Pre-placement Medical Evaluations. The fire service requires a pre-placement medical evaluation for all fire fighter candidates, regardless of age. Components of the evaluation include the following:

- A complete medical history
- Physical examination
- Vital signs including height and weight
- Vision testing (acuity, color, peripheral)
- Audiogram

- Blood analysis: serum chemistry, lipid panel, liver profile, and complete blood count
- Urinalysis (dipstick)
- Drug screen
- Pulmonary function test (spirometry)
- Chest x-ray
- 12-lead resting electrocardiogram (EKG)
- Tuberculosis skin test (PPD)
- Hepatitis screening if vaccination not complete (Hepatitis B)

Periodic Evaluations. Annual medical evaluations are required by the FD with a more comprehensive medical examination conducted depending on the age of the member. The annual medical evaluation includes a medical and occupational history, a Tuberculosis screen, a vision screen (acuity and color), vital signs including height and weight, and immunization maintenance. The more comprehensive medical examination occurs every 3 years for fire fighters under the age of 30, every 2 years for fire fighters between the ages of 30 and 39, and every year for fire fighters 40 years of age and above. The content of this examination is the same as the pre-placement except there is no chest x-ray (unless clinically indicated), and the resting EKG and lipid profile are done annually beginning at age 35. Medical clearance for respirator use is required annually.

Fire fighters injured at work or off work due to illness must be evaluated by the infirmary. The infirmary then forwards a recommendation regarding return to work to the Fire Chief.

Exercise (strength and aerobic) equipment is located in the fire station. Mandatory fitness programs are in place for training each shift. A physical ability test is performed every year on all fire fighters. The health/wellness program consists of health educational and smoking cessation programs.

DISCUSSION

There are four possible causes of the death of this AFF:

1) Cardiomyopathy leading to an arrhythmia and then sudden cardiac death
2) Myocardial bridging leading to ischemia and then sudden cardiac death
3) Combination of 1 & 2
4) SCD of unknown origin

Left ventricular hypertrophy. The AFF had left ventricular hypertrophy on autopsy. 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 chronic cardiac ischemia (reduced blood supply to the heart muscle). However the AFF was never known to have had high blood pressure, and, on autopsy, did not have any valve abnormalities. His unexplained cardiac hypertrophy could represent a condition called hypertrophic cardiomyopathy (HCM). This conclusion of HCM is supported by the following findings: 1) enlarged heart, 2) thickened left heart ventricles, and 3) microscopic findings of myocyte hypertrophy. The pathologist conducting the autopsy also mentioned a "mild right ventricular dilatation." Because no heart chamber measurements were included it is difficult to determine whether the AFF really had a mixed hypertrophic and dilated cardiomyopathy.

Hypertrophic cardiomyopathy is a relatively rare heart condition, affecting approximately 0.2% of the population.[1] Most patients are asymptomatic, and sudden cardiac death is often HCM's first clinical manifestation, particularly among patients less than 30 years of age.[2] Risk factors for sudden death among HCM patients include young age (<30 years old) at diagnosis, a family history of HCM with sudden death, an abnormal blood pressure response to exercise, severe symptoms (i.e. marked shortness of breath, chest pain, fatigue, dizziness, overt congestive heart failure), non-sustained ventricular tachycardia, marked hypertrophy, marked left atrial dilatation, and genetic abnormalities associated with increased prevalence of a sudden death.[1-3]

Approximately half of HCM cases have a genetic origin, typically in an autosomal dominant trait with

disease loci on at least eight different chromosomes.[4] Genetic testing, however, is not routinely available and remains largely a research tool. The causes of HCM in the other half of patients are of unknown etiology (idiopathic).[2]

Myocardial Bridging. MB is defined as occurring when a portion of a coronary artery tunnels into the myocardium creating a muscle-bridge overlap. MB is very common. It has been reported in 0.5% to 16% of angiographic studies and 15% to 85% of autopsies.[5] Compression of the coronary artery due to the muscular band occurs during systole and sometime extends into diastole. It has been reported to be associated with SCD,[6-9] ischemia,[10-12] myocardial infarction,[13-17] arrhythmia,[18-20] and coronary artery spasm[21]. Because of the commonness of MB, its relationship to SCD is less clear.

MB has been found in up to 30% of patients diagnosed with HCM.[22,23] Some studies have hypothesized that MB explains the myocardial ischemia frequently seen in HCM.[22,24-27] Other researchers, however, believe that bridging in HCM can cause perfusion abnormalities, but not MIs, arrhythmias, or SCD.[28]

To reduce the risk of sudden cardiac deaths and other medical conditions among fire fighters, the NFPA has developed the NFPA 1582 guideline entitled *Comprehensive Occupational Medicine Program for Fire Departments*.[29] The 2003 edition recommends a comprehensive medical examination be performed **annually** on all members. A physical exam was performed on this fire fighter and, according to his father, no abnormalities were found. This exam probably included at least one resting EKG. Resting EKGs, however, are very poor screening tests for HCM or myocardial bridging. An echocardiogram is a good screening test for HCM, but neither the American Heart Association/American College of Cardiology nor the NFPA 1582 recommend echocardiograms for asymptomatic candidates or members.

RECOMMENDATIONS

It is unlikely the following recommendation could have prevented the AFF's death. Nonetheless, the NIOSH investigator offers this recommendation to reduce the risk of sudden cardiac arrest among fire fighters.

Recommendation #1: Provide annual medical evaluations consistent with the 2003 edition of NFPA 1582.

The FD's medical evaluation and examination, while comprehensive, appears to be based on the 1997 and 2000 editions of NFPA 1582. In the fall of 2003, NFPA issued a significantly revised edition. A copy of the 2003 edition has been provided to the FD.

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