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NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation *August 29, 2006*

Fire Fighter/Emergency Medical Technician (FF/EMT) Suffers Sudden Death While On-Duty – South Carolina

SUMMARY

On March 31, 2006, the FF/EMT arrived for duty at his fire station (Station 4) at 0745 hours. The three crew members assigned to Station 4 checked their fire apparatus and equipment, and then the FF/EMT washed the station's vehicles (one engine and one ambulance). No calls or alarms were received by Station 4's crew during the day. At approximately 1630 hours the FF/EMT was last seen walking around the apparatus bay. At 1656 the FF/EMT was found lying face down, unresponsive, without a pulse or respirations in the apparatus bay. Despite cardiopulmonary resuscitation (CPR) performed at the station, and advanced cardiac life support (ACLS) performed in the ambulance and in the emergency department (ED) of the local hospital, the FF/EMT died. The death certificate, completed by the examining physician in the hospital's ED, listed the immediate cause of death as "probable cardiac arrhythmia," due to "seizures," due to "epilepsy." The autopsy, completed by the county coroner's office, concluded the FF/EMT most likely died of a "sudden unexplained ventricular arrhythmia or possible seizure." The NIOSH investigator concurs with this conclusion.

The NIOSH investigators offer these recommendations to reduce the risk of on-the-job sudden death among fire fighters.

***Encourage fire fighters to provide accurate medical history information to the FD physician. This can be accomplished by emphasizing the importance of this information during training sessions. Physicians providing medical clearance for duty should be knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of National Fire Protection Association (NFPA) 1582,* Standard on Comprehensive Occupational Medicine Program for Fire Departments.**

Although unrelated to this fatality, the FD should consider the following recommendation to improve their overall safety and health program.

Conduct exercise stress tests (EST) for fire fighters at increased risk of ischemic heart disease.

Discontinue resting electrocardiograms (EKGs) performed as part of the annual medical evaluation program.

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

Phase in a physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting.

Use a secondary (technological) test to confirm appropriate placement of the endotracheal (ET) tube during emergency intubations.

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/fire

or call toll free **1-800-35-NIOSH**

Fire Fighter/Emergency Medical Technician (FF/EMT) Suffers Sudden Death While On-Duty – South Carolina

Conduct periodic testing of ACLS equipment and refresher ACLS training for fire fighter/paramedics.

INTRODUCTION & METHODS

On March 31, 2006, a 34-year-old male FF/EMT suffered sudden death at his fire station. On April 3rd, NIOSH was notified of the fatality and on April 21st contacted the affected FD to gather information regarding the fatality. On July 26th, an Occupational Medicine Physician from the NIOSH Fire Fighter Fatality Investigation and Prevention Team traveled to South Carolina to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel met with or interviewed the following people:

- County Risk Manager
- Fire Chief
- Crew members on duty with the FF/EMT
- Other fire fighters involved in the resuscitation effort
- Assistant Fire Chiefs
- Office staff of the FF/EMT's primary care physician

During the site visit NIOSH personnel reviewed the following documents related to this incident:

- Crew member statements
- Dispatch records
- Ambulance response report
- ED record of the resuscitation effort
- Death certificate
- Autopsy report
- County coroner's report
- The FF/EMT's primary care physician medical records
- The FF/EMT's training records at the FD

INVESTIGATIVE RESULTS

On March 31, 2006, at 0745 hours, the FF/EMT arrived at his fire station for duty. He was assigned to Station 4 with two other crew members (one FF/paramedic and one FF/EMT). The three crew members began their 24-hour shift by checking their fire apparatus and equipment and then had breakfast. Later that day, the FF/EMT washed the station's vehicles (one engine and one ambulance). No calls or alarms were received by the crew during the day. At no time during the day did the FF/EMT express any symptoms of not feeling well or show any signs of discomfort.

At approximately 1630 hours the FF/EMT was last seen by crew members walking around the apparatus bay. At 1656 hours the station received a phone call from a Battalion Chief who wanted to speak with the FF/EMT. A crew member answered the phone and entered the apparatus bay to notify the FF/EMT about the phone call. The crew member saw the FF/EMT lying face down on the floor under a hose reel. She shouted his name, but he did not respond. She yelled for the other crew member as she shook the FF/EMT to wake up. She then rolled him onto his back where he took one gasp (an agonal respiration). The other crew member retrieved the stretcher and they loaded him into Station 4's ambulance where vital signs were taken. He was unresponsive with no pulse or spontaneous breathing. As they began CPR they notified dispatch (1657 hours) that they needed back-up for a cardiac arrest.

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Two volunteer fire fighters arrived at the station about three minutes later (1700 hours) and took over CPR while the crew members began ACLS. A cardiac monitor, which they attached to the FF/EMT, showed no heart beat (asystole). Oxygen was supplied via a bag-value-mask as chest compressions continued. After three unsuccessful attempts at intubation (breathing tube placed into the airway), the ambulance departed the station at 1707 hours for the hospital's ED.

At 1709 hours another FD paramedic, responding to the dispatch in his personal vehicle, met the ambulance en route to the ED. This paramedic was able to intubate the FF/EMT and proper tube placement was confirmed by auscultation (listening with a stethoscope) over the chest, but confirmatory testing (e.g., a secondary technology test) was not done. At the same time crew members started an intravenous (IV) line and IV medications were administered according to ACLS protocols. At approximately 1720 hours, with no change in the FF/EMT's clinical condition, cardiac pacing was attempted. Apparently, there were problems charging the leads of the PhysioControl® Life Pack and cardiac pacing was not successful.

The ambulance arrived at the hospital's ED at 1729 hours. The ED physician noted a concern about the endotracheal tube being dislodged from the trachea, so the FF/EMT was re-intubated by the ED physician with "oral tracheal tube seen passing through the vocal cords, good endtidal CO_2 response [secondary technology test], [and] good breath sounds following intubation."

CPR and ACLS continued for 15 minutes in the ED. At 1744 hours, the FF/EMT was pronounced dead and resuscitation efforts were stopped. The FF/EMT received a total of over 45 minutes of CPR and ACLS with no change in his clinical status.

Medical Findings. The death certificate, completed by the examining physician in the hospital's ED, listed the immediate cause of death as "probable cardiac arrhythmia," due to "seizures," due to "epilepsy." An autopsy was performed by the County Coroner's Office. Significant findings included the following:

- Normal sized heart, 350 grams (normal < 400 grams)
- No plaque, atherosclerosis, or blockages in any of the coronary arteries
- Two coronary arteries (the left anterior descending and the right coronary artery) had "small diameters within their distal distribution"
- No microscopic evidence of cardiomyopathy (a medical condition that is associated with an increased risk of sudden cardiac death)
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- No evidence of an intra-cranial hemorrhage (stroke)
- Negative blood drug test for illegal drugs
- Positive blood drugs test for methobarbitol and phenobarbital. The phenobarbital level of 8.9 micrograms per milliliter (ug/mL) was sub-therapeutic for a seizure disorder (10-30 ug/mL). A blood level for dilantin was not conducted.

These autopsy findings did not point to a definitive cause of death, therefore the county coroner concluded the FF/EMT most likely died of a "sudden unexplained ventricular arrhythmia or possible seizure."

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The FF/EMT had a long history of a seizure disorder (epilepsy). A local community medical clinic had been following the FF/EMT for this condition since 1997. He was maintained on anti-seizure prescription medications consisting of dilantin (alternating 200 and 300 milligrams per day) and phenobarbitol (100 milligrams per day). According to interviews and records available to NIOSH at the time of this report, the FF/EMT had three seizures of the generalized tonic-clonic type within the past five years (April 2001, December 2003, April 2004). Two seizures were attributed to sub-therapeutic doses of dilantin (reported as a compliance problem) and one seizure was attributed to an elevated level of dilantin. He was last seen by his treating physician in September 2005 at which time his phenobarbital blood levels were in therapeutic range at 21 ug/mL, but his dilantin level was low (2.1 ug/mL, therapeutic range 10-20 ug/mL). At that time his dilantin dosage was not increased because the FF/EMT had no seizures for almost a year and a half on this regimen. The FD's contract physician conducting the post-offer/preplacement and annual medical evaluations was not aware of the FF/EMT's seizure disorder.

DESCRIPTION OF THE FIRE DEPARTMENT

This FD consists of approximately 120 career and 150 volunteer fire fighters serving a population of 65,000 residing within an 814-square-mile area. Fire fighters wanting a career position with the FD or volunteers wanting to conduct interior fire suppression must pass a post-offer/preplacement medical evaluation conducted by a physician group under contract with the FD. Components of this medical evaluation include the following:

- Complete medical and occupational history
- Height, weight, and vital signs
- Physical examination
- Blood tests: complete blood count with differential, chemistry panel (SMA 18), lipid panel, iron levels, and thyroid function tests
- Urine tests: urinalysis with microscopy, urine drug screen
- 12-lead resting EKG
- Audiometry
- Spirometry
- Vision test: Snellen vision screen, visual acuity, visual field, color vision

Once this evaluation is complete, the physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the County's Fire Chief. In 2003, when the FF/EMT applied to become a career fire fighter with the FD, he did not check the epilepsy (seizure) box on his medical history form.

Career fire fighters and volunteers conducting interior fire suppression must also have an annual medical evaluation conducted by the same Fire Department contracted physician group doing the post-offer/pre-placement medical evaluations. The content of this medical evaluation is the same as the post-offer/pre-placement evaluation except the illicit drug test is not repeated. This evaluation not only provides medical clearance to conduct fire suppression duties, but also provides medical clearance for the fire fighter to wear a respirator. During the FF/EMT's FD medical evaluation in 2005, and again in 2006, he did not check the epilepsy box on the medical history form. His last FD medical evaluation in

January 2006 revealed the following two abnormalities: a) a slightly slow heart rate on his EKG (sinus bradycardia with a heart rate of 56 beats per minute, normal 60-100) and b) a high total cholesterol and LDL cholesterol, but a normal total cholesterol/HDL cholesterol ratio.

The FD conducts annual respirator fit tests, but does not conduct physical ability/agility tests or offer a fitness/wellness program. The FD does, however, provide exercise equipment (strength and aerobic) in all fire stations and allow fire fighters to exercise while on-duty.

DISCUSSION

Epilepsy is defined as a condition characterized by two or more unprovoked seizures.[1] Epileptics can be categorized by the following medical characteristics:

- Frequency of seizures (in-remission versus active, which is defined as more than one seizure over the past five years)[1]
- Etiology (cause): idiopathic (unknown) versus remote symptomatic (central nervous system lesion with or without neurodeficits)[1]
- Seizure type: generalized tonic-clonic (GTC), versus partial, versus other

The FF/EMT had active idiopathic epilepsy of the GTC type.

The overall death rate of epileptics is significantly increased relative to the general population with epileptics having up to a three-fold higher rate.[2] The following risk factors have been consistently associated with an increased death rate among epileptics: etiology (remote symptomatic > idiopathic), seizures type (GTC > partial or other), and duration (short and long > intermediate).[3-6] When cause-specific mortality is examined, death rates due to all types of heart disease are not increased, however a few studies show some heart disease subsets have increased rates. These include ischemic heart disease and myocardial insufficiency.[3,6,7]

The death of patients with epilepsy may be unrelated to epilepsy, related to the underlying cause of epilepsy, or related to seizures, but the increase death rate observed in epileptics is primarily due to the underlying cause of epilepsy.[3] The following discussion explores this topic in more detail as it relates to this investigation.

Sudden Unexpected Death in Epilepsy (SUDEP) is a term defined as "sudden, unexpected, witnessed or unwitnessed, nontraumatic and nondrowning deaths in patients with epilepsy, with or without evidence of a seizure and excluding documented status epilepticus, in which post-mortem examination does not reveal a toxicologic or anatomic cause of death."[8] The mechanism is unclear, but it may involve autonomic or cardiorespiratory disturbances.[9,10] Rates of SUDEP range from 0.3 to 1.0 per 1,000 person-years in unselected populations,[11-14] to rates as high as 10 per 1,000 person-years in high risk individuals (e.g., surgical candidates for refractory seizures).[15,16] In one study, the rate of SUDEP among 20-40 year olds was 24 times the rate of sudden death among 20-40 year olds in the general population.[11] When witnessed, only GTC seizures have been reported with SUDEP.[11] In addition to GTC seizures, risk factors for SUDEP include seizure frequency (>1 seizure during the year of observation), seizure onset at an early age, and long duration of the seizure disorder.[17] The FF/EMT had several of these risk factors.

Although the FF/EMT met the case definition and had several risk factors for SUDEP, since

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his event was unwitnessed, it is not possible to determine definitively that his death was seizure related. Thus, NIOSH investigators agree with the conclusion of the county coroner who determined the cause of death to be "sudden unexplained ventricular arrhythmia or possible seizure."

RECOMMENDATIONS

The NIOSH investigators offer these recommendations to reduce the risk of on-the-job sudden death among fire fighters.

***Recommendation #1: Encourage fire fighters to provide accurate medical history information to the FD physician. This can be accomplished by emphasizing the importance of this information during training sessions. Physicians providing medical clearance for duty should be knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of National Fire Protection Association (NFPA) 1582,* Standard on Comprehensive Occupational Medicine Program for Fire Departments.**

Physicians who provide input regarding medical clearance for fire fighting duties should be knowledgeable about the physical demands of fire fighting and understand that fire fighters frequently work in dangerous environments, particularly if the fire fighter becomes incapacitated. The physicians 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*.[18]

NFPA 1582 lists epilepsy with a seizure during the previous five years as a precluding condition for applicants because it "interfere[s] with a member's ability to safely perform essential job tasks…".[18] The FF/EMT failed to notify the FD physician of his seizure disorder (epilepsy) and his prescribed anti-seizure medications. Had the FD physician been notified of this condition, perhaps the FF/EMT would have been re-assigned to duties within the FD and/or been required to have closer blood monitoring of his anti-seizure medications. Re-assigning the FF/EMT to alternate duty is unlikely to have prevented his death. However, more frequent monitoring of his anti-seizure medications and/or better medication compliance may have prevented the FF/EMT's death at this time.

Although unrelated to this fatality, the FD should consider the following recommendations to improve their overall safety and health program.

Recommendation #2: Conduct exercise stress tests (EST) for fire fighters at increased risk of ischemic heart disease.

In addition to screening for coronary artery disease (CAD) risk factors, NFPA 1582 recommends EST for some asymptomatic (i.e., no symptoms of angina) fire fighters. Conducting EST on asymptomatic individuals is somewhat controversial due to false positive and false negative test results. NFPA 1582 recommends, not as a part of the requirements but for informational purposes only, an EST for fire fighters with two or more risk factors for CAD. The Standard lists the following criteria for CAD risk factors: hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (systolic greater than 140 mm Hg or diastolic greater than 90 mm Hg),

smoking, diabetes, or family history of premature CAD (cardiac event in first degree relative less than 60 years old).[18]

This recommendation is similar to the American College of Cardiology/American Heart Association (ACC/AHA).[19] The ACC/AHA considers the evidence to be in favor of conducting EST in asymptomatic individuals with diabetes mellitus, but "less well established" (Class IIb) for:

1. Asymptomatic men older than 45 years, and women older than 55 years who are sedentary and plan to start vigorous exercise;
2. Asymptomatic men older than 45 years, and women older than 55 years who are involved in occupations in which impairment might jeopardize public safety (e.g., fire fighters);
3. Asymptomatic men older than 45 years, and women older than 55 years who are at high risk for CAD due to other diseases (e.g., peripheral vascular disease and chronic renal failure)

Given the FF/EMT's age and lack of CAD risk factors, neither NFPA or the ACC/AHA would have recommended an EST. Even if an EST was conducted, however, it is unclear if it would have identified the FF/EMT's predisposition to sudden death.

Recommendation #3: Discontinue resting electrocardiograms (EKGs) performed as part of the annual medical evaluation program.

Guidance regarding the content and frequency of pre-placement and periodic medical evaluations and examinations for structural fire fighters can be found in NFPA 1582.[18] NFPA 1582 recommends a baseline EKG at the time of hire, and annually thereafter, however it also concludes "periodic resting electrocardiograms have not been shown to be useful but can be reasonable as a member's age increases."[18] The Report of the U.S. Preventative Services Task Force does not recommend yearly EKGs for asymptomatic individuals.[20] The NIOSH investigator concludes annual resting EKGs in asymptomatic individuals without heart disease is an unnecessary expense for the FD.

Recommendation #4: Phase in a 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. Physical inactivity, or lack of exercise, is associated with other CAD risk factors: obesity and diabetes.[21] NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[22] 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 their disability pension costs.[26] Guidance for how to implement and components of a wellness and fitness program include:

- NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters;* [27]
- International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC), *Fire Service Joint Labor Management Wellness/Fitness Initiative;*[28]

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- National Volunteer Fire Council (NVFC) / United State Fire Administration (USFA) *Health and Wellness Guide for the Volunteer Fire Service*.[29]

NIOSH has supplied the FD with these documents.

Recommendation #5: Phase in a 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 FD members who engage in emergency operations to be annually evaluated and certified by the FD as having met the physical performance requirements identified in paragraph 8-2.1.[19] A test for candidates, Candidate Physical Ability Test (CPAT), had been developed by the IAFF/IAFC.[30] NIOSH has supplied the FD with a CD ROM containing the CPAT.

Recommendation #6: Use a secondary (technological) test to confirm appropriate placement of the endotracheal (ET) tube during emergency intubations.

To reduce the risk of improper intubation, the AHA and the International Liaison Committee on Resuscitation published recommendations in the Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.[31] These guidelines recommend confirming tube placement by primary and secondary methods. Primary confirmation is the 5-point auscultation: left and right anterior chest, left and right midaxillary, and over the stomach. Secondary confirmation requires a technology test, either an end-tidal carbon dioxide detector or an esophageal detector device. In this incident, the FF/EMT had bilateral breath sounds confirmed by auscultation, however, secondary confirmation was not performed by FD personnel. While it is very unlikely the FF/EMT was improperly intubated, it is mentioned here to ensure future resuscitation efforts follow published protocols.

Recommendation #7: Conduct periodic testing of ACLS equipment and refresher ACLS training for fire fighter/paramedics.

During the FF/EMT's resuscitation attempt, the FD staff noted a problem using the non-invasive (external) pacer of the Lifepak®10. The Assistant Chief of Medical Operations was notified of this problem and contacted Medtronic, the manufacturer and service provider. A vendor with the manufacturer tested the unit and reported that it was operating adequately.

The FD should consider reporting the incident to the Food and Drug Administration (FDA). MedWatch is the FDA's program for reporting, among other things, product use errors with medical devices. An online reporting form is available at this link: https://www.accessdata.fda.gov/scripts/medwatch/medwatch-online.htm.

In addition, the NIOSH investigator recommends the FD conduct refresher ACLS training to all FF/EMTs. This should help the fire department be consistent with American Heart Association guidelines regarding intubation procedures, and become more proficient with the external pacing device.

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INVESTIGATOR INFORMATION

This investigation was conducted, and the report written by Thomas Hales, MD, MPH. Dr. Hales is the team leader of the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio.

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