



Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

April 28, 2006

Captain Suffers Pulmonary Embolism During Response to a Medical Call and Later Dies – New York

SUMMARY

On November 4, 2005, a 38-year-old male volunteer fire Captain was home when the fire department (FD) was dispatched to a medical call. As he began to respond, he collapsed. His wife found him getting up and complaining of breathing difficulty. He asked her to take him to the hospital instead of calling 911. Before he could get dressed, he collapsed again and his wife called 911. FD units and a mutual aid ambulance were dispatched and provided basic life support (BLS). En route to the hospital's emergency department (ED), the Captain became unresponsive, stopped breathing, and was pulseless. Ambulance service emergency medical technicians (EMTs), and FD crew members began cardiopulmonary resuscitation (CPR). Despite CPR and BLS performed by FD crew members and ambulance service EMTs, and advanced life support (ALS) performed by hospital ED personnel, the Captain died. The death certificate (completed by the County Coroner) and the autopsy (completed by the forensic pathologist) listed "pulmonary emboli (PE) due to probable deep vein thrombosis (DVT)" as the cause of death. The NIOSH investigator concluded that PE caused the Captain's sudden death.

To reduce the risk of sudden cardiac arrest among fire fighters, NIOSH investigators offer the following recommendations:

Provide pre-placement and annual medical evaluations in accordance with National Fire Protection Association (NFPA) 1582 to determine fire fighters' medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

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

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

INTRODUCTION & METHODS

On November 4, 2005, a 38-year-old male fire Captain suffered a pulmonary embolism at home as he started to respond to a medical call. He suffered a cardiac arrest while being transported to the hospital. Despite BLS, CPR, and ALS performed by FD crew members, ambulance service personnel, and hospital ED personnel, the Captain died. The United States Fire Administration notified NIOSH of this fatality on November 4, 2005. NIOSH contacted the affected FD on November 7, 2005, to obtain further information, and on November 8, 2005, to initiate the investigation. On December 5, 2005, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation and Prevention Team traveled to New York to conduct an on-site investigation of the incident.

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

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During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- Third Assistant Chief
- FD Assistant Chief for Emergency Medical Services (EMS)
- Crew members
- Captain's wife

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

- FD incident reports
- FD training records
- FD standard operating guidelines
- FD annual response report for 2004
- Witness statements
- FD physical evaluation records
- Primary care physician records
- Ambulance report
- Hospital ED report
- Death certificate
- Autopsy report

INVESTIGATIVE RESULTS

On November 4, 2005, the Captain was home sleeping on the couch when his wife arrived home from work (0730 hours). She continued through the house into the bedroom and went to bed. At 0849 hours, the Captain's FD was dispatched to a medical call. As the Captain got up to respond to the call, he collapsed. His wife awoke after hearing the town fire whistle, and also after hearing him fall. Thinking he had tripped and fallen, she went out to check on him and found him lying on the floor. After he arose, the Captain told his wife to take him to the hospital because he was having difficulty breathing. He collapsed again before he could get dressed and his wife called 911 (0903 hours).

The FD and a local ambulance were dispatched. FD units began arriving on the scene at 0906 hours and found the Captain lying on his right side, grabbing his chest, reporting crushing chest pain, sweating profusely, and having breathing difficulty; his skin color was pale and ashen. While crew members obtained oxygen equipment, a semi-automated external defibrillator (SAED) was attached to the Captain. Since the first ambulance was responding to the previous call, another ambulance crew was summoned. A mutual aid ambulance from a neighboring district was then requested (0909 hours) and that ambulance responded (0911 hours). The SAED revealed normal sinus rhythm with tachycardia (rapid heart rate of 126 beats per minute). Oxygen was given to the Captain via a non-rebreather mask, but he had great difficulty in keeping the mask on due to its confining nature, his pain, and his restlessness. His blood pressure could not be taken due to his restlessness. Pulse oximetry revealed a blood oxygen level of 71% (normal is >90%). His respiratory rate was 38 breaths per minute (normal is 10-14 per minute).

The mutual aid ambulance arrived on the scene at 0920 hours. EMTs found the Captain diaphoretic (sweating) and pale in color with signs of respiratory distress (respiratory rate of 10 breaths per minute and shallow) and chest pain. His blood pressure was 167/129 millimeters of mercury (mmHg) and his pulse rate was 100 beats per minute. He was placed onto a backboard and stretcher and loaded into the ambulance. The ambulance departed the scene at 0927 hours en route to the hospital. At 0928 hours, the Captain became unresponsive, stopped breathing, and was pulseless. An oral airway was inserted, and CPR was begun. He was placed on a cardiac monitor, which advised personnel not to shock. The ambulance arrived at the hospital ED at 0932 hours.

ALS, including intubation (breathing tube inserted into the trachea) and intravenous (IV) line placement, was performed inside the ED. Tube placement was confirmed by syringe aspiration test. The cardiac monitor revealed pulseless electrical activity (abnormal heart rhythm incapable of sustaining life)



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at first, then fine ventricular fibrillation (Vfib). After one defibrillation attempt, the Captain's heart rhythm reverted to asystole (no heart beat). ALS resuscitation measures continued without any improvement in the Captain's condition. At this point, the Captain had been in cardiopulmonary arrest in the ED for 47 minutes. At 1019 hours, the attending physician pronounced the Captain dead, and resuscitation measures were discontinued.

Medical Findings. The death certificate (completed by the County Coroner) and the autopsy (completed by the forensic pathologist) listed "pulmonary emboli (PE) due to probable deep vein thrombosis (DVT)" as the cause of death. The autopsy, performed on November 5, 2005, included the following findings:

- Evidence of diffuse PE in both lungs
- Swollen right lower leg
- Mild hypertensive CVD:
 - No significant coronary artery atherosclerosis
 - Left ventricle walls slightly thickened/hypertrophied (1.6 centimeters [cm]) (normal is 0.6 cm - 1.1 cm)¹
 - Right ventricle walls slightly thickened/hypertrophied (0.6 cm) (normal is 0.3 cm - 0.5 cm)²
- Cardiomegaly (enlarged heart): heart weighed 540 grams (g) (normal is <400 g)³
- No microscopic examination of the heart muscle was performed
- Negative drug screen

The Captain had visited his primary care provider three weeks prior to his death. His visit was routine, but he had complaints of right lower leg swelling and had gained 59 pounds within the last six months. He had complained of chest pain the night before this episode but did not seek medical treatment. He had no previous history of DVTs, PEs, or clotting disorders.

His other medical conditions included hypertension, hypercholesterolemia, hypertriglyceridemia, and obesity/lack of physical exercise. He had not been prescribed medications to lower his blood pressure, cholesterol, or triglyceride levels.

At autopsy, the Captain weighed 320 pounds and was 69 inches tall, giving him a body mass index (BMI) of 47.2 kilograms per square meter (kg/m^2). A BMI $>40.0 \text{ kg}/\text{m}^2$ is considered extreme obesity.⁴ According to the Captain's wife, he did not perform regular strenuous exercise, but remained active by bowling and golfing.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this volunteer FD consisted of 45 uniformed personnel, served a population of 2,800 in an 18.9 square-mile area, and had one fire station.

In fiscal year 2004, the FD responded to 200 calls including the following: 11 structure fires, 2 vehicle fires, 3 brush/grass fires, 4 outside rubbish fires, 1 other fire, 29 motor vehicle accidents, 7 hazardous condition calls, 11 false alarm calls, 5 carbon monoxide calls, 5 flooding calls, 4 search and rescue calls, 3 police assist calls, 3 good intent calls, 2 other rescue calls, 109 EMS calls, and 1 other call.

Membership and Training. The FD requires all fire fighter applicants to possess a valid state driver's license; pass a pre-placement physical examination; pass an interview by the membership committee; be voted on by the fire company; and pass a background check prior to being accepted as a member. The new member has two years to complete the voluntary State Fire Fighter 1 certification. New members have up to six months to complete the physical examination. There are no State minimum standards for volunteer fire fighters. New York is an Occupational Safety and Health Administration (OSHA) State-plan State,⁵ and paid and volunteer FDs are required to comply with OSHA standards.



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The Captain was certified as a Fire Fighter 2 and a Driver/Operator. He had 21 years of firefighting experience and was a former Assistant Chief.

Pre-placement Physical Examination. A pre-placement physical examination is required for all candidates. The components of the examination are as follows:

- Medical history
- Vital signs
- Physical examination
- Spirometry
- Resting electrocardiogram (EKG)
- Chest x-ray if over age 40

Periodic Evaluations. Semi-annual medical evaluations are required for all members. The evaluations consist of the following:

- Medical history
- Vital signs
- Physical examination
- Spirometry
- Resting EKG
- Chest x-ray if over age 40

Medical evaluations are performed by a FD contract physician for fire fighters who do not receive medical evaluations through their primary work or their personal insurance. If the evaluations are not provided by the FD contract physician, the FD pays the insurance deductible. Medical clearance is provided to the Fire Chief, who makes the final determination for fitness for duty. No physical agility test is required by this FD. There is no wellness/fitness program and no exercise equipment available for use. A return-to-duty medical clearance is required for injuries that prevent fire fighters from performing their duties. A State worker's compensation physician provides the clearance if the injury is duty-related. If the injury is not duty-related, the member's primary care physi-

cian provides the clearance, which is forwarded to the Fire Chief, who makes the final determination for return-to-duty. Semi-annual self-contained breathing apparatus (SCBA) medical clearances are required and are included in the periodic medical evaluation. The Captain's last FD medical evaluation was in October 2002 and he was cleared for full duty. He last visited his primary care physician in October 2005 for obesity. He was considering gastric bypass surgery. His right calf was swollen during that visit. A venous Doppler exam of the right leg did not reveal any evidence of a deep vein thrombosis.

DISCUSSION

DVT and the Pathophysiology of Sudden Cardiac Death.

A DVT is a blood clot (thrombus) that develops in a deep vein, usually in the leg. It is more commonly seen in adults over age 60, but can occur in any age group. Risk factors for its development include prolonged sitting, bedrest or immobilization (such as on long plane or car trips), recent surgery or trauma (especially hip, knee or gynecological surgery), fractures, childbirth within the last 6 months, use of medications such as estrogen and birth control pills, polycythemia vera, malignant tumors, obesity, prior phlebitis, and inherited or acquired hypercoagulability (changes in the levels of blood clotting factors making the blood more likely to clot).^{6,7}

Symptoms of a DVT can include swelling of the leg, warmth and redness of the leg, or pain exacerbated by standing or walking.^{6,8,9} Many DVT patients do not experience these symptoms.⁸ Signs on physical examination (e.g., swelling, erythema, tenderness, superficial venous dilation, appearance of prominent venous collaterals, a palpable "cord," or a positive Homan sign) often are not evident.⁷⁻⁹ Therefore, it is generally accepted that clinical signs are unreliable and the lack of physical findings does not rule out a DVT.^{9,10} In this case, however, the Captain visited his primary care provider three weeks prior to his death with complaints of right calf hardness and



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swelling which “had been going on for quite some time.” “Sometimes his right calf becomes very hard and swollen.” A venous Doppler test was performed by a radiologist in October 2005, but did not reveal a DVT.

Diagnosing a DVT is important so treatment can be initiated before complications develop. D-Dimer, a degradation product of cross-linked fibrin, is often elevated in patients with venous thrombosis. It is a sensitive, but not specific, test for venous thrombosis.⁹ The noninvasive test used most often to diagnose DVT is duplex venous ultrasonography (B-mode, i.e., two-dimensional, imaging, and pulse-wave Doppler interrogation).⁹ The sensitivity of duplex venous ultrasonography approaches 95% for proximal DVT and 75% for symptomatic calf vein thrombosis.⁹ Magnetic resonance imaging (MRI) is another noninvasive means to detect DVT. Its diagnostic accuracy for assessing proximal DVT is similar to that of duplex ultrasonography.⁹ DVT can also be diagnosed by venography. The presence of a filling defect or absence of filling of the deep veins is required to make the diagnosis.⁹

DVT must be differentiated from a variety of disorders that cause unilateral leg pain or swelling, including muscle rupture, trauma, or hemorrhage. It may be difficult to distinguish swelling caused by the postphlebitic syndrome from that due to acute recurrent DVT. Leg pain may also result from nerve compression, arthritis, tendonitis, fractures, and arterial occlusive disorders. A careful history and physical examination can usually determine the cause of these symptoms.⁹

Prevention of PE is the most important reason for treating patients with DVT, since in the early stages the thrombus may be loose and poorly adherent to the vessel wall.⁹ Treatment with blood thinners can help prevent the clot from becoming larger, new clots from forming, development of post-thrombotic syndrome, and most importantly, the blood clot from breaking loose and traveling to the lungs (pulmonary

embolus [PE]).^{6,11} Symptoms of a PE include shortness of breath, pleuritic chest pain, and coughing up phlegm, possibly flecked with blood. Depending on the size of the clot, a PE can be life-threatening. With appropriate treatment (e.g., blood thinners), it is rare for a DVT to lead to a PE.¹¹ However, 50% of untreated patients with DVT developed PE and 20% died from PE.^{9,12} The Captain had complained of chest pain the night before this event, but did not seek medical treatment.

The autopsy findings confirmed the presence of diffuse (scattered) PE, but not the presence of a DVT in the right leg. It is possible the thrombus had completely embolized and traveled to the lungs or had not originated in the specific site sectioned at autopsy. Regardless, the Captain had a history of right lower leg swelling.

The Captain’s only risk factor for a DVT was obesity. Therefore, the origin of his “probable” DVT remains unclear. The PE was not identified until the autopsy. His cardiac arrest was medically treated as a cardiac condition. Thus, medical treatment to dissolve the PE was not administered.

At autopsy, the Captain also had slight left and right ventricular thickening/hypertrophy and cardiomegaly. These conditions increase the risk of congestive heart failure (CHF). LVH 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). The Captain had an 8-year history of high blood pressure, therefore this condition was most likely responsible for his left ventricular hypertrophy and right ventricular hypertrophy.

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the NFPA developed NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments*.¹³ NFPA



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1582 considers peripheral vascular disease (arterial or venous) if the fire fighter is symptomatic (claudication) or has severe peripheral edema to potentially interfere with such essential job tasks as fire fighting, climbing stairs while wearing full turnout gear, advancing hoselines, and prolonged exertion.¹³ NFPA 1582 considers thrombophlebitis and/or deep venous thrombosis if it is recurrent, persistent, or requires full dose anticoagulation, to potentially interfere with the same essential job tasks.

While a mandatory, comprehensive wellness/fitness program (including dietary education and exercise) would have benefited this fire fighter, it is unclear if that alone would have prevented his death at this time.

RECOMMENDATIONS

To reduce the risk of sudden cardiac arrest among fire fighters, NIOSH investigators offer the following recommendations:

Recommendation #1: Provide pre-placement and annual medical evaluations in accordance with NFPA 1582 to determine fire fighters' medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Guidance regarding the content and frequency of pre-placement and periodic medical evaluations and examinations for structural fire fighters can be found in NFPA 1582,¹³ in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) *Wellness/Fitness Initiative*,¹⁴ and the National Volunteer Fire Council (NVFC) *Health and Wellness Guide*.¹⁵ The FD is not legally required to follow any of these standards.

Applying this recommendation involves economic repercussions and may be particularly difficult for small, rural, volunteer FDs to implement. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, Chapters 8-7.1 and 8-7.2¹⁶ and the NVFC *Health and Wellness Guide*¹⁵ address these issues.

Recommendation #2: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for CVD 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.¹⁷ NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.¹⁵ NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*, provides guidance for a health-related fitness program.¹⁸

In 1997, the IAFF and the 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 FDs across the United States pooled information about their physical fitness programs and created a practical fire service program. They produced a manual and a video which detail elements of such a program.¹⁴ 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 FD, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.²² The NVFC *Health and Wellness Guide* addresses wellness/fitness programs as they relate to volunteer FDs.¹⁵

Recommendation #3: Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural firefighting.

NFPA 1500 requires FD members who engage in emergency operations to be evaluated annually, and to be certified by the FD as having met the physical performance requirements identified in paragraph 8-2.1.¹⁶



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