



Fire Apparatus Driver Operator Experiences Chest Pain While Exercising at Fire Station and Dies Three Days Later due to a Pulmonary Embolus – Maryland

SUMMARY

On January 9, 2008, a 36 year old Fire Apparatus Driver Operator (D/O) reported for duty at 0700 hours. Later that afternoon the D/O began walking on an exercise treadmill – a sanctioned activity that the Fire Department (FD) encourages while on-duty. While exercising, the D/O experienced chest discomfort. After being evaluated by a paramedic in the station, the D/O was transported and admitted to a local hospital. A number of medical tests were conducted focusing on a cardiac etiology including a cardiac catheterization which revealed no significant coronary artery disease. The D/O was discharged two days later (January 11) and instructed to report to the Fire Department's health care provider for a "return to work" evaluation. On January 12, the D/O collapsed at his residence. An advanced life support (ALS) unit responded to the scene and found the D/O in severe respiratory distress. Upon arrival in the hospital's emergency department, the D/O went into cardiac arrest. Despite advanced life support (ALS) provided by personnel in the emergency department, the D/O died. The autopsy listed "occlusive bilateral pulmonary thromboembolism" [pulmonary embolism (PE)] as the cause of death.

Given the cause of death, it is unlikely the Fire Department (FD) could have prevented the

death of this D/O. Therefore, the following recommendations address general health and safety issues facing this FD and the Fire Service in general. NIOSH offers the following recommendations to reduce the risk of on-the-job cardiovascular events among fire fighters at this and other fire departments across the country.

- *Provide mandatory annual medical evaluations to all fire fighters consistent with the National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.*
- *Develop a comprehensive wellness/fitness program for fire fighters to reduce risk factors for cardiovascular (CVD) and improve cardiovascular capacity.*

INTRODUCTION & METHODS

On January 9, 2008, a 36-year-old career D/O experienced chest pain/discomfort while walking on a treadmill at the fire station. Despite medical evaluation in the hospital for 2 days, the D/O collapsed and died at his home, 1 day after discharge from the hospital. The autopsy revealed the cause of death to be a PE.



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NIOSH was notified of this fatality on January 14, 2008 by the United States Fire Administration. NIOSH contacted the affected fire department shortly thereafter to obtain additional information. On May 21, 2009, NIOSH again contacted the department to request further information and to schedule the investigation. On June 23 and 24, 2009, a contractor for the NIOSH Fire Fighter Fatality Investigation Team (the NIOSH investigator) travelled to Maryland to conduct an on-site investigation of the incident.

During the investigation, the NIOSH investigator met with and/or interviewed the following individuals:

- Fire Chief
- Director of Fire Safety
- Local Union President
- Medical Examiner
- Crew members of the volunteer FD that responded to the D/O's collapse at his home
- D/O's girlfriend
- D/O's mother

The NIOSH investigator reviewed the following documents in preparation of this report:

- Fire department's internal investigation report
- Ambulance report
- Death certificate
- Autopsy

- Hospital records (from separate hospitals that provided: initial cardiac testing, cardiac catheterization, care during fatal event, occupational health care)

INVESTIGATIVE RESULTS

Initial Incident. On January 9, 2008, the D/O reported to duty at 0610 hours for his day shift after 4 days off duty. Shortly after arriving at the fire station the D/O performed assigned duties, including checking the apparatus and assisting with routine housework. At 1000 hours the D/O presented a hazardous materials refresher class to shift personnel. His coworkers noted nothing out of the ordinary and the D/O reported no pain or discomfort. The D/O was not dispatched to any emergency calls prior to 1415 hours when he went to the exercise area and began walking on a treadmill. After walking about 4 minutes, the D/O experienced dizziness, shortness of breath, and chest tightness that radiated to the left shoulder, arm, and jaw. The on-duty paramedic at the station attached a cardiac monitor to the D/O's chest, but did not see any abnormalities. At this point the D/O told the Captain that "something serious was going on with him" and he was transported by the station's medic unit to the local hospital (about 1500 hours). Hospital records indicate that the D/O was evaluated in the emergency department for chest pain resulting in a hospital admission. The D/O reported exercising regularly, but never having episodes like this. Prior to this incident he denied having exertional chest pain, dyspnea on exertion, orthopnea, palpitations, dizziness, or syncope. He



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reported no history of hypertension, diabetes, coronary artery disease, asthma, emphysema, or family history of heart or lung problems.

The hospital performed an electrocardiogram (ECG) that showed incomplete right bundle branch block (a heart conduction problem) with slight T-wave inversions. Blood tests were negative for a heart attack. A chest x-ray showed mild cardiomegaly with a slight prominence of the pulmonary artery segment, but no congestive heart failure or other changes suggestive of a pulmonary embolus.

The following day, January 10, 2009, the D/O had an imaging stress test using the Bruce protocol. The D/O exercised for a total of 8 minutes and 8 seconds achieving about 10 metabolic equivalents (METs) (75% of age-predicted maximal exercise capacity) and a heart rate of 166 beats per minute (90% of his maximal predicted heart rate). The D/O stopped exercising at this point due to fatigue, dizziness, and faintness. In fact, as the treadmill was coming to a stop, the D/O slumped to the floor and briefly lost consciousness (syncope). During the stress test his blood pressure increased from his resting blood pressure of 136/100 millimeters of mercury (mmHg) to 200/90 mmHg and then down to 88/60 mmHg when he slumped to the floor. The D/O was quickly revived and his blood pressure returned to normal with lying flat and intravenous (IV) fluid administration. The D/O reported no chest area pain or discomfort during or after exercise. The cardiac monitor showed no arrhythmias or evidence of ischemia on his electrocardiogram (ECG). In fact, the D/O's slight T-wave abnormality

normalized with exercise although some non-specific ST-T abnormalities in the lateral leads appeared after his syncopal episode. The imaging portion of the stress test revealed normal left ventricular function at rest (left ventricular ejection fraction = 50%) and no evidence of transient ischemic changes during increased cardiac work. A transthoracic echocardiogram found a mildly enlarged right ventricular cavity (3.81 cm), but a normal left ventricular structure and function.

At this point, the D/O was transferred to another hospital for a cardiac catheterization. The cardiac catheterization showed that the D/O did not have significant coronary artery disease and the D/O was discharged with instructions to avoid heavy lifting and operating a vehicle for 2 days. He was instructed to see the Fire Department's health care provider on January 14, 2009 for "return to work" medical clearance.

Fatal Incident. On January 12 at approximately 1152 hours, the D/O's girlfriend heard him collapse and witnessed what she described as seizure-like behavior at his residence. An ALS unit was dispatched to the residence at 1154 hours and arrived at 1202 hours. The ALS team found the D/O in severe respiratory distress and began ventilating him via bag-valve mask. His blood pressure was 89/46 mmHg with a pulse of 144 and agonal respirations. Because of the D/O's agitated state, his oxygen saturation could not be obtained. The D/O was placed on a stretcher and ventilation was continued via bag-valve mask. Attempts to start an intravenous line were unsuccessful.



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The ambulance left the scene at approximately 1211 hours. During transport the D/O became increasingly agitated and Emergency Medical Service (EMS) personnel were not able to obtain a blood pressure. Approximately 1 minute away from the hospital his heart rate dropped to 75 beats per minute and his respiratory rate increased to 16 breaths per minute. As the D/O was being wheeled into the hospital he went into cardiac arrest (about 1220 hours).

Upon arrival at the hospital's emergency department, the D/O was unresponsive in respiratory and cardiac arrest. The D/O was intubated at 1224 hours with proper placement confirmed by breath sounds and end tidal carbon dioxide measurement. IV lines were placed and cardiac drugs, including epinephrine and atropine, were administered per ALS protocols. The patient remained asystolic throughout the resuscitation effort. After approximately 27 minutes of ALS care without a change in his clinical condition, the D/O was pronounced dead at 1247 hours.

Medical Findings. An autopsy was performed by an Assistant Medical Examiner in the Office of the Chief Medical Examiner. The cause of death was listed as "occlusive bilateral pulmonary thromboembolism." This term essentially means that blood clots from the D/O's legs traveled to his lungs where they blocked the lung's blood circulation. Blood clots (occlusive thromboemboli) were found throughout the D/O's pulmonary circulation. The autopsy also revealed a wedge-shaped, dark purple infarct in the lung's right lower lobe (2" wide tapered to 1/2"). The appearance of this lung in-

farct was consistent with a recent thromboembolism, probably from January 9, 2008, when the D/O first experienced symptoms. The medical examiner also found blood clots in his lower right leg (also known as a deep vein thrombosis – DVT) which were the source of the blood clots in his lungs (emboli). Appendix A contains pertinent autopsy findings.

Reports from the family and review of the occupational health records of this fire fighter provide no indication of major injury to the lower limb or history of surgery that would have increased the likelihood of a DVT.

DESCRIPTION OF THE FIRE DEPARTMENT

The FD employs over 1000 career fire fighters and has operational control over many local volunteer fire departments. The FD staffs 25 fire stations and serves a population of approximately 800,000 residents, covering an area of approximately 600 square miles.

Employment, Preplacement Medical Evaluation, and Training. The FD requires applicants to take a general aptitude test, complete a physical ability test, and be interviewed. Top candidates must pass a pre-placement medical evaluation before they are hired. Components of this medical evaluation were not available to the NIOSH contractor at the time of this report. The D/O was hired in 1997 and was a certified Emergency Medical Technician and had received training in Hazardous Materials operations.



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Periodic Medical Evaluations. The FD does not require annual medical evaluations for members, but they do require medical evaluations at the time of promotions. The contractor performing these promotional medical evaluations was unable to locate the D/O’s medical records at the time of this report.

Fitness/Wellness Programs. The FD does not have a comprehensive fitness and wellness program. Individual fire stations have some aerobic exercise equipment and exercise is encouraged, however, there is no mandatory exercise program or fitness requirement.

DISCUSSION

The D/O died of “occlusive bilateral pulmonary thromboemboli” and at autopsy was found to have blood clots in the veins of his right leg (DVT).

DVT. 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 can be grouped into a) vein/leg problems or b) blood problems. The vein/leg problems include prolonged sitting, bedrest or immobilization (e.g., long plane or car trips), recent surgery or trauma (especially hip, knee or gynecological surgery), fractures, or child-birth within the last 6 months. Blood problems stem from a susceptibility to form blood clots due to medications (e.g., estrogen and birth control pills), medical conditions (e.g., polycythemia vera or cancer), or inherited or

acquired hypercoagulability states [National Institute of Health 2009; Gupta and Stoufer 2001].

Symptoms of a DVT can include swelling of the leg, warmth and redness of the leg, or pain exacerbated by standing or walking [National Institutes of Health 2009; Leclerc et al. 1991]. Like the D/O, many DVT patients do not experience these symptoms [Leclerc et al. 1991; Creager and Loscalzo 2008]. Many patients also lack signs on physical examination (e.g., swelling, redness, tenderness, superficial venous dilation, appearance of prominent venous collaterals, a palpable “cord,” or a positive Homan sign) [Gupta and Stoufer 2001; Leclerc et al. 1991]. Therefore, the lack of symptoms and the unreliable physical findings make the diagnosis of a DVT very challenging [Gorman et al. 2000; Golhaber 2007].

A strong association exists between DVT and PE [Kearon et al. 2001]. In fact, DVT and PE are considered different stages and clinical presentation of the same process, collectively termed venous thromboembolism [Kearon, et al. 2001]. In general, a DVT is not life-threatening, but large PE can be fatal. The probability of a clot progressing from DVT in the calf, to DVT in the thigh, to PE depends on the severity of the initial stimulus to form a clot and the ability of the body to breakdown the clot [Kearon et al. 2001].

The D/O was reportedly in very good health and exercised regularly. The D/O did have two possible risk factors for a DVT [Golhaber 2007]. These included a possible fam-



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ily history of DVT/PE, suggesting a possible familial coagulopathy, and an increased body mass index (BMI) of 30.6 which is indicative of obesity according to CDC standards [CDC 2008]. Although he had an elevated BMI, his coworkers and the medical examiner described the D/O as very muscular and not obese. Additionally, the D/O was an African American and epidemiological evidence suggests that African Americans have a higher incidence of DVT than Caucasians [Kearon et al. 2001].

Pulmonary Embolus. Venous thromboembolism afflicts a wide range of individuals and causes several hundred thousand deaths in the United States each year. Symptoms of a PE include shortness of breath, pleuritic chest pain, and coughing up phlegm, possibly flecked with blood. Like DVTs, small PE can be asymptomatic with non-specific physical findings and therefore are difficult to diagnose [Bettmann et. al. 2006].

PE is a common cause of sudden and often unexpected death. In many instances the correct diagnosis is not made until after death. In an autopsy study conducted between 1985 -1990, PE was the cause of death in 3.8% of the cases. In these PE deaths, a PE was not suspected as the cause of death in 68% of cases [Morganthaler and Ryu 1995].

RECOMMENDATIONS

It is unlikely the FD could have done anything to prevent the death of this D/O. Therefore, the following recommendations address gen-

eral health and safety issues facing this FD and the Fire Service in general. NIOSH offers the following recommendations to reduce the risk of on-the-job cardiovascular events among fire fighters at this and other fire departments across the country.

Recommendation #1: Provide mandatory annual medical evaluations to all fire fighters consistent with the National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

Guidance regarding the content and frequency of periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582 and in the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) Fire Service Joint Labor Management Wellness/Fitness Initiative [IAFF/IAFC 2007; NFPA 2007]. This FD requires medical evaluations for new recruits but does not require annual medical evaluations for all personnel. It is possible, though not likely, that a routine medical examination would have identified the DVT earlier and prevented the PE responsible for this firefighter's death.

Recommendation #2: Develop a 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. Physical inactivity, or lack of exercise, is an independent risk factor for CAD and it is positive-



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ly associated with other risk factors including, obesity, dyslipidemia, and diabetes [Plowman and Smith 2003]. NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being [NFPA 2002]. The D/O was reported to be a regular exerciser and in very good physical condition. Reduced fitness is a risk for the metabolic syndrome and cardiovascular disease [Donovan 2009; Kodama 2009]. Additionally, a comprehensive wellness program would offer an opportunity to address a variety of health-related issues, including hypertension and smoking cessation. An effective wellness and fitness program has the potential to improve health and performance, decrease cardiovascular risk factors, and enhance safety on the fireground. Guidance for how to implement and what to include in a wellness and fitness program can be found in several documents provided by Fire Service organizations:

- NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters [NFPA 2008];
- International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC), Fire Service Joint Labor Management Wellness/Fitness Initiative [IAFF/IAFC 2007];

REFERENCES

Bettmann MA, Lyders EM, Yucel EK, Khan A, Haramati LB, Ho VB, Rozenshtein A, Rybicki FJ, Schoepf UJ, Stanford W, Woodard PK, Jaff

M, (Expert Panel on Cardiac Imaging) [2006]. Acute chest pain--suspected pulmonary embolism. [http://www.guideline.gov/summary/summary.aspx?doc_id=10600]. Date accessed: October 29, 2009.

CDC (Centers for Disease Control and Prevention) [2008]. BMI – Body Mass Index. [http://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/english_bmi_calculator/bmi_calculator.html]. Date accessed: September 30, 2009.

Creager MA, Loscalzo J (2008). Vascular diseases of the extremities. In Fauci AS, Braunwald E, Kasper DL, Hauser SL, Longo DL, Jameson JL, Loscalzo J eds., *Harrison's Principles of Internal Medicine*, 17th ed., New York: McGraw-Hill, pp.1568-1575.

Donovan R, Nelson T, Peel J, Lipsey T, Voyles W, Israel RG [2009]. Cardiorespiratory fitness and the metabolic syndrome in fire fighters. *Occup Med* 59:487-492.

Golhaber S [2007]. Pulmonary Embolism. In: Libby P, Bonow RO, Mann DL, Zipes DP, eds. *Braunwald's Heart Disease: A textbook of cardiovascular medicine*. 8th Edition. Philadelphia:Saunders, pp 1863-1881.

Gorman WP, Davis KR, Donnelly R [2000]. ABC of arterial and venous disease. Swollen lower limb-1: general assessment and deep vein thrombosis. *Brit Med J* 320:1453-6.

Gupta R, Stouffer GA [2001]. Deep venous thrombosis: A review of the pathophysiology, clinical features, and diagnostic modalities. *Am J Medical Sciences* 322:358-364.



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IAFF/IAFC [2007]. The fire service joint labor management wellness/fitness initiative. Washington, DC: International Association of Fire Fighters, International Association of Fire Chiefs.

Kearon C, Salzman EW, Hirsh J [2001]. Epidemiology, Pathogenesis, and Natural History of Venous Thrombosis. In: Colman RW, Hirsh J, Marder VJ, Clowes AW, George JN, eds. Hemostasis and Thrombosis: Basic principles and clinical practice. Philadelphia: Lippincott Williams & Wilkins, pp. 1153-1177.

Kodama S, Saito D, Tanaka S, Maki M, Yachi Y, Asumi M, Sugawara A, Totsuka K, Shimano H, Ohashi Y, Yamada N, Sone H [2009]. Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: a meta-analysis. JAMA; 301:2024-35

Leclerc JR, Illescas F, Jarzem P [1991]. Diagnosis of deep vein thrombosis. In : Leclerc JR, editor. Venous Thromboembolic Disorders. Philadelphia: Lea & Febiger, p.176.

Morganthaler TI and Ryu JH [1995]. Clinical characteristics of fatal pulmonary embolism in a referral hospital. Mayo Clin Proc 70:417-424.

NFPA (National Fire Protection Association) [2002]. NFPA 1500: Standard on Occupational Safety Program for Fire Departments. Quincy, MA: National Fire Protection Association.

NFPA (National Fire Protection Association) [2007]. NFPA 1582: Standard on comprehensive occupational medical program for fire departments. Quincy, MA.

NFPA (National Fire Protection Association) [2008]. NFPA 1583: Standard on health-related fitness programs for fire fighters. Quincy, MA.

National Institutes of Health. <http://www.nlm.nih.gov/medlineplus/deepveinthrombosis.html> Accessed on August 14, 2009.

Plowman SA, Smith DL [2003]. Exercise physiology: for health, fitness and performance. 2nd edition. San Francisco: Benjamin Cummings.

INVESTIGATOR INFORMATION

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio. Denise L. Smith, Ph.D, led the investigation and co-authored the report. Dr. Smith is professor of Exercise Science, and holds the Class of 1961 Chair at Skidmore College. She was working as a contractor with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component during this investigation. Thomas Hales, MD, MPH, provided medical consultation and coauthored the report. Dr. Hales is a member of the NFPA Technical Committee on Occupational Safety and Health, and Vice Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).



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Appendix A

Pertinent Autopsy Findings

- Coronary arteries followed the usual distribution and were without evidence of significant atherosclerosis or thrombosis.
- The pulmonary arteries had occlusive thromboemboli of the major arteries and of the smaller arteries.
- There was a wedge-shaped (2” wide tapered to ½ “), dark purple infarct in the lower lobe of the right lung.
- There were deep vein thrombi in the right lower leg.
- Blood tests were negative for alcohol and other elicited drugs.

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In fiscal year 1998, the Congress appropriated funds to NIOSH to conduct a fire fighter initiative. NIOSH initiated the Fire Fighter Fatality Investigation and Prevention Program to examine deaths of fire fighters in the line of duty so that fire departments, fire fighters, fire service organizations, safety experts and researchers could learn from these incidents. The primary goal of these investigations is for NIOSH to make recommendations to prevent similar occurrences. These NIOSH investigations are intended to reduce or prevent future fire fighter deaths and are completely separate from the rulemaking, enforcement and inspection activities of any other federal or state agency. Under its program, NIOSH investigators interview persons with knowledge of the incident and review available records to develop a description of the conditions and circumstances leading to the deaths in order to provide a context for the agency's recommendations. The NIOSH summary of these conditions and circumstances in its reports is not intended as a legal statement of facts. This summary, as well as the conclusions and recommendations made by NIOSH, should not be used for the purpose of litigation or the adjudication of any claim. For further information, visit the program website at

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