2019
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Death in the line of duty...

National Institute for Occupational Safety and Health NIOSH

A report from the NIOSH Fire Fighter Fatality Investigation and Prevention Program September 1, 2019

30-Year-Old Lieutenant Dies in Sleep Following Department Training—Vermont

Executive Summary

On February 28, 2018, a 30-year-old male paid on call lieutenant was found deceased in his bed after having completed fire department training the night before. The Medical Examiner's report listed the cause of death as atherosclerotic cardiovascular disease noting that there was a finding of severe, focal atherosclerosis in the left anterior descending artery and a history of hypertension. National Institute for Occupational Safety and Health (NIOSH) investigators concluded that the training exercises may have triggered a sudden cardiac event in an individual with atherolsclerosis and hypertension. However, the precise cause of the death is unclear as no thrombus was found and the heart did not have clear evidence of major structural changes.

Key Recommendations

NIOSH offers the following recommendations to help reduce the risk of sudden cardiac events among firefighters at this and other fire departments across the country.

- *Ensure that all firefighters receive an annual medical evaluation consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.*
- *Ensure firefighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting and the personal protective equipment used by firefighters as per NFPA 1582.*
- *Phase in a comprehensive wellness and fitness program for firefighters.*

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Introduction

On February 28, 2018, a 30-year-old male paid on call lieutenant (LT) was found deceased in his bed after having completed fire department training the night before. The U.S. Fire Administration notified National Institute for Occupational Safety and Health (NIOSH) of this fatality on March 2, 2018. On August 27, 2019, a contractor for the NIOSH Fire Fighter Fatality Investigation and Prevention Program (the NIOSH investigator) conducted an on-site investigation of the incident.

During the investigation, the NIOSH investigator interviewed the following people:

- *Fire Chief*
- *Assistant Fire Chief*

The NIOSH investigator reviewed the following documents:

- *Fire department (FD) incident reports for previous day*
- *Emergency medical services (EMS) (ambulance) report*
- *Fire Department medical exam records*
- *Primary Care medical records*
- *Death certificate*
- *Autopsy report*

Investigation

On February 27, 2018, at approximately 1830 hours the FD began weekly training that involved securing a water supply in cold weather. The training included cutting a hole through ice on a pond, getting water to the engine, and then operating hoselines. The training lasted about three hours. The lieutenant (LT) oversaw training activities and demonstrated several techniques but did not enter the water. The LT showed no signs of discomfort or distress during the evening. At about 2200 hours, the LT left the station and returned to his home.

Notes taken by EMS personnel indicate that the LT's fiancé noticed him snoring at 2300 hours. In the morning, the fiancé realized he was not breathing and had no signs of life. She called 911 at 0614 hours.

An advanced cardiac life support level 1 ambulance was dispatched at 0615 hours. Upon arrival at 0628 hours, the EMS crew found the LT in bed; he was pulseless, apneic, and his skin was a bluish

gray. Cardiopulmonary resuscitation (CPR) was initiated. A cardiac monitor was attached to the LT but a shock was not advised. CPR was continued for seven rounds over the course of approximately 20 minutes; a pause to check the cardiac monitor revealed that the LT remained in asystole. At 0646 hours, after consultation with medical command, the LT was pronounced dead.

Medical Findings

The medical examiner identified the cause of death as atherosclerotic cardiovascular disease. The heart weight was within normal range (410 grams; normal range: 280–486 grams) with left ventricular wall thickness was normal (1.1 centimeters [cm] electrocardiogram [ECG]; normal range 1.07 cm–1.39 cm) [Silver and Silver 2001]. The myocardium was firm throughout with no indication of softness or scarring suggesting that the LT had not had a heart attack that caused death of the heart muscle. There was marked atherosclerosis of the proximal section of left anterior descending artery resulting in an 80% occlusion of the vessel. There was no evidence of blood clots causing a blockage in any of the coronary arteries.

The LT did not have any pre-existing medical conditions on joining the FD in 2013 and the medical evaluation conducted as a part of his application process was unremarkable. At his preplacement medical evaluation, he was noted to have normal blood pressure 118/78 millimeters of mercury (mmHg) (normal is < 120/80 [Whelton et al. 2017]). There were few medical records for the LT. However, he did visit the emergency department in 2010 for gastroenteritis. At that visit, he had a blood pressure of 119/85. Routine blood tests at that time showed low high-density lipoprotein (HDL) (HDL = 26 milligrams/deciliter [mg/dL]; normal > 40 mg/dL), normal total cholesterol (167 mg/dL; normal < 200 mg/dL) and normal LDL cholesterol (108 mg/dL; normal < 130 mg/dL), and an abnormal cholesterol/HDL ratio, which is associated with increased risk of cardiovascular disease [Kratz et al. 2004]. The LT completed a questionnaire for medical clearance to wear a self-contained breathing apparatus (SCBA) and indicated that he had no cardiovascular/heart problems (including hypertension) and no symptoms related to cardiovascular or heart disease. He also indicated that he was not taking any prescription medication.

The LT was a former-smoker, having quit about 2 years before his death. He did not exercise regularly. He was approximately 67 inches tall and weighed 196 pounds, giving him a body mass index (BMI) of 30.2 kilograms per meter squared (kg/m^2). A BMI over 30 kg/m^2 is considered to be obese [NHLBI no-date-a].

Fire Department

At the time of the NIOSH investigation, the career fire department consisted of one fire station with approximately 25 uniformed personnel. The FD served a population of approximately 5,000 in a 75 square mile area.

Applicants who wish to join the FD must be at least 16 years old. Applicants submit an application, are interviewed by a membership committee, must pass a criminal background check, be medically cleared (discussed below) and are then voted on by the membership. New members serve a 6 months probationary period before becoming full members.

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Medical Evaluations/Wellness/Fitness Programs

The FD requires preplacement medical evaluations for applicants. The medical evaluation is performed by a physician contracted to the town administration. The components of the medical evaluation include:

- Complete medical history
- Physical examination (height, weight, blood pressure, pulse, and respiratory rate)
- Respirator use questionnaire

The FD does not offer periodic evaluations for members. A respiratory fit test for SCBA use is performed every year. Members must provide a medical clearance following a serious injury or illness. A physician contracted by the town administration makes the final determination on return to work. The FD does not offer a fitness programs or equipment, but members have access to wellness programming through the town administration.

Discussion

Sudden Cardiac Events

Sudden cardiac events are most often caused by myocardial infarction (heart attack) or cardiac arrest (fatal arrhythmias). In the United States, atherosclerotic coronary heart disease (coronary artery disease) is the most common risk factor for cardiac arrest and sudden cardiac death [Myerburg and Castellanos 2008].

Coronary Artery Disease

Risk for the development of atherosclerosis is grouped into non-modifiable and modifiable risk factors. Non-modifiable risk factors include age older than 45, male sex, and family history of coronary artery disease. Modifiable risk factors include diabetes mellitus, smoking, high blood pressure (hypertension), unhealthy blood cholesterol levels, and obesity/physical inactivity [AHA 2016; NHLBI no-date-b]. The LT had one non-modifiable risk factor (male sex) and two documented modifiable risk factors, obesity and smoking.

Hypertensive Heart Disease

Interactions between genetic factors and hemodynamic factors cause hypertensive heart disease in individuals with arterial hypertension [Diamond and Phillips 2005]. Hypertensive heart disease results in anatomical and functional changes to the heart and vessels as a consequence of long-standing hypertension (abnormally elevated blood pressure). Left ventricular hypertrophy (LVH), due to myocyte enlargement, is a reflection of hypertensive end-organ damage, which can lead to increase an enlarged heart, abnormal perfusion (blood flow to the heart), congestive heart failure (condition where the heart cannot pump effectively and fluid backs up into the lungs and/or extremities), and arrhythmias (abnormal heart rhythms that can be life-threatening) [Prisant 2005]. In addition to chronic hypertension, LVH can also be caused by a heart valve problem, obesity, or cardiac ischemia (reduced

blood and oxygen supply to the heart muscle) [Siegel 1997; Tavora et al. 2012]. LVH is also associated with sleep apnea [Smith et al. 2018]. The autopsy found that the LT had left ventricular wall thickness within expected range [Silver and Silver 2001] but the medical examiner reported that the heart had a dilated/globular appearance. Although the LT was obese based on BMI standards, he did not have any evidence of heart valve abnormalities at autopsy.

Sudden Cardiac Death of Unknown Cause

Most victims of sudden cardiac events have cardiac abnormalities (known or unknown). The most common findings at autopsy include: coronary artery disease, hypertrophic cardiomyopathy, ventricular hypertrophy, and valvular stenosis [Kahan and Bergfeldt 2005; Wever and Robles de Medina 2004]. However, in some cases, the cause of sudden cardiac death is unclear at autopsy. In these cases, sudden cardiac death may be due to problems with the heart's electrical conduction system that tells the muscles of each chamber when to contract or coronary artery spasm [Katritsis et al. 2016].

Occupational Medical Standards for Structural Firefighters

Nearly half of all firefighter duty-related deaths are caused by sudden cardiac death. Firefighting results in multiple cardiovascular changes that could lead to plaque rupture, thrombus formation, or arrhythmogenic changes in individuals with underlying cardiovascular disease [Smith et al. 2016]. Research relying on autopsy data suggests that the majority of firefighter duty-related sudden cardiac deaths have atherosclerosis and/or cardiomegaly [Smith et al. 2018] and this is also true for young (< 45 years) firefighters [Yang et al. 2013]. To reduce the risk of sudden cardiac events or other incapacitating conditions among firefighters, the NFPA developed 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments* [NFPA 2013, 2018]. Guidance in the 2018 edition of the 1582 Standard recommends annual risk assessment of all firefighters ≥ 40 years old with a "Heart Risk Calculator" that takes into account age, sex, blood pressure, smoking status, etc., to estimate 10-year risk of sudden cardiac events or stroke [ACC/AHA 2019; NFPA 2018]. The LT did not receive periodic medical evaluations, but even if he had, a risk score would not have been recommended based on his young age.

NIOSH offers the following recommendations to help reduce the risk of sudden cardiac events among firefighters at this and other fire departments across the country.

Recommendations

Recommendation #1: Ensure that all firefighters receive an annual medical evaluation consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

Discussion: Guidance regarding the content and frequency of these medical evaluations can be found in NFPA 1582 [NFPA 2018]. These evaluations are performed to determine a firefighter's medical ability to perform duties without presenting a significant risk to the safety and health of himself/herself or others. This medical evaluation should be consistent with the requirements of NFPA 1582.

Recommendation #2: Ensure firefighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by firefighters, and the various components of NFPA 1582.

Discussion: According to NFPA 1582, the FD should require that physicians are familiar with the physical demands of fire fighting and the risks that firefighters encounter and should guide, direct, and advise members with regard to their health, fitness, and suitability for duty [NFPA 2018]. The physician should review job descriptions and essential job tasks required for all FD positions to understand the physiological and psychological demands of fire fighting and the environmental conditions under which firefighters perform, as well as the personal protective equipment they must wear during various types of emergency operations.

Recommendation #3: Phase in a mandatory comprehensive wellness and fitness program for firefighters.

Discussion: Guidance for fire department wellness/fitness programs to reduce risk factors for cardiovascular disease and improve cardiovascular capacity is found in NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters* [NFPA 2015], the *IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative (WFI),* [IAFF and IAFC 2008], *Firefighter Fitness: A Health and Wellness Guide* [Schneider 2010] *and* the *Health and Wellness Guide for the Volunteer Fire and Emergency Services* [USFA 2009]. Health promotion programs for firefighters have been shown to reduce coronary heart disease risk factors and improve fitness levels, with mandatory programs showing the most benefit [Blevins et al. 2006; Dempsey et al. 2002; Womack et al. 2005].

References

ACC/AHA [2019]. Atherosclerotic cardiovascular disease risk estimator plus. Washington, DC: American College of Cardiology; Dallas, TX: American Heart Association, http://tools.acc.org/ASCVD-Risk-Estimator-Plus/#!/calculate/estimate/.

AHA [2016]. Understand your risks to prevent a heart attack. Dallas, TX: American Heart Association, http://www.heart.org/HEARTORG/Conditions/HeartAttack/UnderstandYourRiskofHeartAttack/Understand-Your-Risk-of-Heart-Attack_UCM_002040_Article.jsp.

Blevins JS, Bounds R, Armstrong E, Coast JR [2006]. Health and fitness programming for fire fighters: does it produce results? Med Sci Sports Exerc *38*(5):S454.

Dempsey WL, Stevens SR, Snell CR [2002]. Changes in physical performance and medical measures following a mandatory firefighter wellness program. Med Sci Sports Exerc *34*(5):S258.

Diamond JA, Phillips RA [2005]. Hypertensive heart disease. Hypertens Res *28*(3):191–202, https://doi.org/10.1291/hypres.28.191.

IAFF, IAFC [2018]. The fire service joint labor management wellness-fitness initiative. Fourth ed. Washington, DC: International Association of Fire Fighters; Fairfax, VA: International Association of Fire Chiefs.

Kahan T, Bergfeldt L [2005]. Left ventricular hypertrophy in hypertension: its arrhythmogenic potential. Heart *91*(2):250–256, https://doi.org/10.1136/hrt.2004.042473.

Katritsis DG, Gersh BJ, Camm AJ [2016]. A clinical perspective on sudden cardiac death. Arrhythm Electrophysiol Rev *5*(3):177–182, https://doi.org/10.15420/aer.2016:11:2.

Kratz A, Ferraro M, Sluss PM, Lewandrowski KB [2004]. Case records of the Massachusetts General Hospital. Weekly clinicopathological exercises. Laboratory reference values. N Engl J Med *351*(15):1548–1563, http://dx.doi.org/10.1056/NEJMcpc049016.

Myerburg RJ, Castellanos A [2008]. Cardiovascular collapse, cardiac arrest, and sudden cardiac death. 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.

NFPA [2013]. NFPA 1582. Standard on comprehensive occupational medical program for fire departments. Quincy, MA: National Fire Protection Association.

NFPA [2015]. NFPA 1583. Standard on health-related fitness programs for fire fighters. Quincy, MA: National Fire Protection Association.

NFPA [2018]. NFPA 1582. Standard on comprehensive occupational medical program for fire departments. Quincy, MA: National Fire Protection Association.

NHLBI [no-date-a]. Calculate your body mass index. Bethesda, MD: National Institutes of Health, National Heart, Lung and Blood Institute, https://www.nhlbi.nih.gov/health/educational/lose_wt/BMI/bmi-m.htm.

NHLBI [no-date-b]. Who is at risk for coronary heart disease? Bethesda MD: National Institutes of Health, National Heart, Lung and Blood Institute, https://www.nhlbi.nih.gov/health-topics/coronary-heart-disease.

Prisant LM [2005]. Hypertensive heart disease. J Clin Hypertens *7*(4):231–238, PMID:15860963.

Schneider EL [2010]. Firefighter fitness: a health and wellness guide. New York: Nova Science Publishers.

Siegel RJ [1997]. Myocardial hypertrophy. In: Bloom S, ed. Diagnostic criteria for cardiovascular pathology acquired diseases. Philadelphia, PA: Lippencott-Raven.

Silver MM, Silver MD [2001]. Examination of the heart and of cardiovascular specimens in surgical pathology. In: Silver MD, Gotlieb AI, Schoen FJ, eds. Cardiovascular pathology. 3rd ed. Philadelphia, PA: Churchill Livingstone.

Smith DL, DeBlois JP, Kales SN, Horn GP [2016]. Cardiovascular strain of firefighting and the risk of sudden cardiac events. Exerc Sport Sci Rev *44*(3):90–97, http://dx.doi.org/10.1249/JES.0000000000000081.

Smith DL, Haller JM, Korre M, Fehling PC, Sampani K, Porto LG, Christophi CA, Kales SN [2018]. Pathoanatomic findings associated with duty-related cardiac death in US firefighters: a case-control study. J Am Heart Assoc *7*(18):e009446, https://doi.org/10.1161/jaha.118.009446.

Tavora F, Zhang Y, Zhang M, Li L, Ripple M, Fowler D, Burke A [2012]. Cardiomegaly is a common arrhythmogenic substrate in adult sudden cardiac deaths, and is associated with obesity. Pathology *44*(3):187–191, https://doi.org/10.1097/PAT.0b013e3283513f54.

USFA [2009]. Health and wellness guide for the volunteer fire and emergency services. Emmitsburg, MD: Federal Emergency Management Agency, United States Fire Administration, Publication No. FA-321, https://www.usfa.fema.gov/downloads/pdf/publications/fa_321.pdf.

Whelton PK, Carey RM, Aronow WS, Casey Jr DE, Collins KJ, Himmelfarb CD, DePalma SM, Samuel Gidding, Jamerson KA, Jones DW, MacLaughlin EJ, Muntner P, Ovbiagele B, Smith Jr SC, Spencer CC, Stafford RS, Taler SJ, Thomas RJ, Williams Sr KA, Williamson JD, Wright Jr JT [2018]. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. J Am Coll Cardiol *71*(19):e127–e248, https://doi.org/10.1161/hyp.0000000000000066.

Wever EFD, Robles de Medina EO [2004]. Sudden death in patients without structural heart disease. J Am Coll Cardiol *43*(7):1137–1144, https://doi.org/10.1016/j.jacc.2003.10.053.

Womack JW, Humbarger CD, Green JS, Crouse SF [2005]. Coronary artery disease risk factors in firefighters: effectiveness of a one-year voluntary health and wellness program. Med Sci Sports Exerc *37*(5):S385.

Yang J, Teehan D, Farioli A, Baur DM, Smith D, Kales SN [2013]. Sudden cardiac death among firefighters ≤ 45 years of age in the United States. Am J Cardiol *112*(12):1962–1967, http://dx.doi.org/10.1016/j.amjcard.2013.08.029.

Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiac and Medical Line-of-Duty Deaths (LODD) Investigations Team, located in Cincinnati, Ohio. Denise L. Smith, Ph.D., led the investigation and authored the report. Dr. Smith is Professor of Health and Human Physiological Sciences and Director of the First Responder Health and Safety Laboratory at Skidmore College, where she holds the Tisch Family Distinguished Professorship. She is also a member of the NFPA Technical Committee on Occupational Safety and Health. Dr. Smith was working as a contractor with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiac and Medical LODD Investigations Team, during this investigation. Wendi Dick, MD, MSPH, provided medical consultation and contributed to the report. Dr. Dick is Lead for the Cardiac and Medical LODD Investigations Team in Cincinnati.

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Appendix A
Autopsy Findings

Structural

- Normal heart weight (heart weighed 410 grams)
- Left ventricular wall thickness within expected range (left ventricular thickness of 1.1 cm)
- Dilated/globular appearance

Microscopic

- Myocardium was without focal lesions

Coronary arteries

- No intracoronary thrombus
- There was marked focal atherosclerosis with 80% stenosis in the proximal section of left anterior descending artery

Normal cardiac valves

No evidence of a pulmonary embolus (blood clot in the lung arteries)

Blood analysis

- Negative for drugs of abuse

Author's Discussion:

Predicted normal heart weight 369 grams (ranges between 280 and 486 grams as a function of sex and body weight), according to research in Silver and Silver [2001].

Left ventricular thickness of 1.1 centimeters (cm) is normal on the basis of postmortem studies by Kitzman et al. [1988] (normal range 1.07 cm–1.39 cm, average 1.23 cm).

REFERENCES

Kitzman DW, Scholz DG, Hagen PT, Ilstrup DM, Edwards WD [1988]. Age-related changes in normal human hearts during the first 10 decades of life. Part II (Maturity): a quantitative anatomic study of 765 specimens from subjects 20 to 99 years old. Mayo Clin Proc *63*(2):137–146, https://doi.org/10.1016/s0025-6196(12)64946-5.

Silver MM, Silver MD [2001]. Examination of the heart and of cardiovascular specimens in surgical pathology. In: Silver MD, Gotlieb AI, Schoen FJ, eds. Cardiovascular pathology. 3rd ed. Philadelphia, PA: Churchill Livingstone.