



Lieutenant Suffers an Acute Aortic Dissection After Physical Fitness Training —North Carolina

Executive Summary

On August 17, 2015, a 40-year-old male career Lieutenant (LT) arrived for duty at his fire station at 0600 hours. He exercised by lifting weights in the fire station gym and running outside. A crewmember arriving at the station at 0735 hours for an emergency medical call found the LT sitting on the dayroom couch unresponsive. Despite cardiopulmonary resuscitation (CPR) and advanced life support, the LT was pronounced dead at the scene.

The death certificate and the autopsy report were completed by the Associate Chief Medical Examiner. The cause of death was listed as “hemopericardium” due to “aortic dissection.”

It is unlikely the following recommendations could have prevented the LT’s death. Nonetheless, the NIOSH investigators offer these recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters.

Key Recommendations

- *Provide annual medical evaluations to all fire fighters consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to identify fire fighters at increased risk for coronary heart disease (CHD)*
- *Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the components of NFPA 1582*
- *Provide fire fighters with medical clearance to wear a self-contained breathing apparatus (SCBA) as part of the fire department’s medical evaluation program*
- *Perform an annual physical ability evaluation*
- *Phase in a mandatory comprehensive wellness and fitness program for fire fighters*

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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 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH Fire Fighter Fatality Investigation and Prevention Program, which examines line-of-duty deaths or on-duty deaths of fire fighters to assist fire departments, fire fighters, the fire service, and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with state or federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the victim, the fire department or those interviewed. The NIOSH report's summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency's recommendations and is not intended to be definitive for purposes of determining any claim or benefit.

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Introduction

On August 17, 2015, a 40-year old career lieutenant (the “LT”) died after suffering an aortic dissection. NIOSH was notified of this fatality on August 18, 2015, by the U.S. Fire Administration. NIOSH contacted the affected fire department on August 18, 2015, to gather additional information and on October 3, 2016, to initiate the investigation. On October 12, 2016, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Investigation and Prevention Program conducted an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Shift Captain
- Fire Chief of the LT’s full-time fire department
- Crew members
- LT’s spouse

NIOSH personnel reviewed the following documents:

- Fire department standard operating guidelines
- Police report
- Ambulance response report
- Death certificate
- Autopsy report
- Fire department medical evaluation records
- Primary care physician records

Investigation

On August 17, 2015, the LT arrived at his fire station at about 0600 hours for his 8-hour shift, which began at 0600 hours. The LT was alone in the fire station at the time. According to crewmembers, he exercised by lifting weights in the fire station gym and by running around the local area. After he ran, he entered the fire station and sat on the dayroom couch. At 0643 hours, the LT texted his wife and asked her to locate his insurance card.

At 0725 hours, the fire department was dispatched to a medical call. A crewmember responding to the station arrived at 0735 hours. He entered the fire station and saw the LT sitting on the dayroom couch. The crewmember yelled at the LT that there was an emergency call. When the LT did not move, the crewmember found the LT unresponsive. He notified Dispatch and requested assistance.

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Another crewmember arrived shortly, placed the LT on the floor, and began CPR. An ambulance arrived at 0741 hours. Paramedics found the LT unresponsive, not breathing, and without a pulse. A cardiac monitor revealed asystole (no heart beat). Mottling and lividity (signs of death) were observed. The coroner was notified. The coroner pronounced the LT dead, assigning a time of death at 0720 hours.

Medical Findings

The death certificate and the autopsy report were completed by the Associate Chief Medical Examiner. They listed “hemopericardium” due to “aortic dissection” as the cause of death. Pertinent findings from the autopsy are listed in Appendix A.

The LT was 75 inches tall and weighed 269 pounds, giving him a body mass index of 33.6 kilograms per meters squared [CDC 2015].

Fire Department

At the time of the NIOSH investigation, the fire department consisted of 1 fire station with 40 uniformed personnel (4 career and 36 volunteer). It served 2,000 residents in a geographic area of 6 square miles.

Employment and Training

The fire department requires all new fire fighter applicants to have a General Education Diploma/high school diploma and a state driver’s license; pass a background check; pass a preplacement medical evaluation (performed by the applicant’s primary care physician); pass a drug screen; pass an interview with the fire department review board; and pass a physical agility test (described in Appendix B). The applicant is then voted on by the fire department membership. The newly selected associate member is on probation for 6 months. After that, the associate member is voted on for full membership. The new member must attend weekly training and the monthly business meeting. The fire department pays for the member to attend Fire Fighter I and II training and Emergency Medical Technician training. The fire department prefers the new member to become certified within 1 year. The LT was certified as a Fire Fighter II, Driver/Operator, EMT-Basic, Fire Officer III, Fire Service Instructor, Fire Inspector, Technical Rescue, and in hazardous materials operations. He was promoted to LT in 2004 and had 12 years of fire fighting experience.

Preplacement and Medical Evaluations/Return to Work Medical Evaluations

The fire department requires preplacement medical evaluations for all applicants. The evaluations are conducted by the applicant’s primary care physician with guidance from the fire department. Components of this evaluation include the following:

- Complete medical history
- Physical examination (including vital signs – height, weight, blood pressure, pulse, and respirations)
- Complete blood count with lipid panel

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- Urinalysis
- Urine drug screen
- Hearing test
- Vision test
- Spirometry
- Resting electrocardiogram

Once this evaluation is complete, the physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the fire chief. A baseline chest x-ray is not required. Medical records obtained by the NIOSH investigator did not indicate the LT had a preplacement medical evaluation when he joined this fire department in 2003. The LT passed a preplacement medical evaluation in 2012 for another local fire department.

Periodic medical evaluations are not required by the fire department. However, most of its members are members of other local emergency agencies and those agencies typically require annual medical evaluations. Some members receive annual medical evaluations at their regular workplace. The fire department offers to pay for annual medical evaluations if a member does not receive an evaluation elsewhere. Medical clearance to wear a respirator is not required. Return to work medical clearance is required for on-duty injuries. The member's primary care physician provides the clearance.

Wellness/Fitness Programs

The fire department does not have a comprehensive wellness/fitness program as recommended by the IAFF/IAFC Wellness Fitness Initiative [IAFF, IAFC 2008]. Fitness equipment (strength and aerobic) is available in the fire station. The fire department provides exercise bikes and the members provide other equipment. An annual physical ability test is not required. The LT exercised regularly by lifting weights, running, and walking.

Discussion

Aortic Dissection

The aorta is the major artery that carries blood from the heart to the rest of the body. The aortic wall is composed of three layers in sequence from the lumen proceeding outwards: the intima, medial, and adventitia. Aortic dissection occurs when the blood enters the medial layer typically after a tear in the intima [Chen et al. 1997; Klompas 2002; Januzzi et al. 2004; Creager and Loscalzo 2015; AHA 2016]. Blood expelled from the heart under high pressure (systole) pushes more blood inside the artery wall, further splitting (dissecting) the aorta. Conditions associated with aortic dissection are listed in Appendix C. The LT had one known risk factor: male gender.

Typical presentation for aortic dissection is the sudden onset of severe chest pain radiating to the back and frequently associated with sweating [Chen et al. 1997; Klompas 2002; Januzzi et al. 2004; Creager and Loscalzo 2015; AHA 2016]. Nonspecific signs during physical examination are differences among carotid, radial, and femoral pulses [Klompas 2002]; differences in blood pressure between the two arms [Singer and Hollander 1996; Von Kodolitsch et al. 2000]; and a heart murmur heard through a

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stethoscope. The LT had not seen a physician since 2012. He did not have any recent symptoms of cardiac problems.

Left Ventricular Hypertrophy (LVH)

On autopsy, the LT was found to have LVH, which increases the risk for sudden cardiac death [Levy et al. 1990]. Hypertrophy of the heart's left ventricle is a relatively common finding among individuals with long-standing hypertension, a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle) [Siegel 1997]. The LT was not diagnosed with hypertension. He did not have heart valve problems. The autopsy did not reveal ischemia. It is unclear what caused his LVH.

Occupational Medical Standards for Structural Fire Fighters

To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the National Fire Protection Association (NFPA) developed NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments [NFPA 2013]. This voluntary industry standard provides (1) the components of a preplacement and annual medical evaluation and (2) medical fitness for duty criteria. Even if the fire department was doing annual medical evaluations as recommended by NFPA 1582, it is unlikely the LT's aortic dissection would have been identified.

Recommendations

Recommendation #1: Provide preplacement and annual medical evaluations to all fire fighters in accordance with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to identify fire fighters at increased risk for CHD.

Discussion: Guidance regarding the content and frequency of these medical evaluations can be found in NFPA 1582 and in the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) *Fire Service Joint Labor Management Wellness/Fitness Initiative* [IAFF, IAFC 2008; NFPA 2013a]. These evaluations are done to determine fire fighters' medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. Following this recommendation will require significant resources and may be difficult to implement. In addition, the fire department has no legal obligation to follow the NFPA standard or the IAFF/IAFC guideline.

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

Discussion: NFPA 1582 requires that the fire department designate a physician responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty [NFPA 2013a]. The physician should review job descriptions and essential job tasks required for all fire department positions to understand the physiological and psychological demands of fire fighters and the environmental conditions under which they must perform, as well as the personal protective equipment they must wear during various types of emergency operations. Currently, the member's primary care physician provides medical clearance for return to work. It is unclear if fire fighters' personal physicians are familiar with the recommendations of NFPA 1582 [NFPA 2013a].

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Recommendation #3: Provide fire fighters with medical clearance to wear SCBA as part of the fire department's medical evaluation program.

Discussion: The Occupational Safety and Health Administration (OSHA) *Revised Respiratory Protection Standard* requires employers to provide medical evaluations and clearance for employees using respiratory protection [29 CFR 1910.134]. These clearance evaluations are required for private industry employees and only for public employees in states operating OSHA-approved state plans. Because North Carolina operates a state OSHA plan [OSHA 2016], the fire department is required to provide medical evaluations for employees using respirators.

Recommendation #4: Perform candidate and annual physical ability evaluations.

Discussion: NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires the fire department to develop physical performance requirements for candidates and members who engage in emergency operations [NFPA 2013b]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2013b]. Once developed by the fire department, the annual evaluation could be performed as part of the annual training program.

Recommendation #5: Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

Discussion: Guidance for fire department wellness/fitness programs to reduce risk factors for cardiovascular disease and improve cardiovascular capacity is found in the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, the National Volunteer Fire Council Health and Wellness Guide, in *Firefighter Fitness: A Health and Wellness Guide*, and in NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, [IAFF, IAFC 2008; USFA 2009; Schneider 2010; NFPA 2015]. Worksite health promotion programs have been shown to be cost effective by increasing productivity, reducing absenteeism, and reducing the number of work-related injuries and lost work days [Pelletier 2009; Baicker et al. 2010]. Fire service health promotion programs have been shown to reduce coronary artery disease risk factors and improve fitness levels, with mandatory programs showing the most benefit [Dempsey et al. 2002; Womack et al. 2005; Blevins et al. 2006; Poston et al. 2013]. A study conducted by the Oregon Health and Science University reported a savings of more than \$1 million for each of four large fire departments implementing the IAFF/IAFC wellness/fitness program compared to four large fire departments not implementing a program. These savings were primarily due to a reduction of occupational injury/illness claims with additional savings expected from reduced future nonoccupational healthcare costs [Kuehl et al. 2013].

The fire department does not offer a wellness/fitness program but exercise equipment is available in the fire station. Given the fire department's structure, the National Volunteer Fire Council program would be applicable [USFA 2009]. NIOSH would recommend a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program.

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardio Disease Component in Cincinnati, Ohio. Mr. Tommy Baldwin (MS) led the investigation and authored the report. Mr. Baldwin is a Safety and Occupational Health Specialist, a National Association of Fire Investigators (NAFI) Certified Fire and Explosion Investigator, an International Fire Service Accreditation Congress (IFSAC) Certified Fire Officer I, and a former Fire

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Chief and Emergency Medical Technician.

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Appendix A Autopsy Findings

- Hemopericardium with 800 cubic centimeters (cc) of partially clotted blood in pericardium
- Aortic dissection
 - Rupture of the dissected segment along the aortic root
 - Microscopic evidence of intimo-medial dissection of aortic wall and adventitial early organizing hemorrhage
- Hypertensive heart disease
 - Cardiomegaly (enlarged heart) (heart weighed 590 grams [g];
 - predicted normal weight based on body length ranges between 321 g and 401 g [Zeek 1942]
 - predicted normal weight as a function of sex, age, and body weight is 432 g (ranges between 327 g and 570 g) [Silver and Silver 2001]
 - Left Ventricular Hypertrophy
 - Left ventricle thickened (1.2 centimeter [cm])
 - Normal at autopsy is 0.76–0.88 cm [Colucci and Braunwald 1997]
 - Normal by echocardiographic measurement is 0.6–1.0 cm [Connolly and Oh 2012]
 - Microscopic evidence of occasional myocyte hypertrophy of the myocardium
- No evidence of coronary artery atherosclerosis or coronary artery thrombus (blood clot)
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Blood tests for drugs and alcohol were negative.

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Appendix B Physical Ability Test

The following physical agility test is to see if the applicant is physically able to perform some basic firefighter tasks. Each applicant will be given a copy to read. Upon understanding what the station consists of, the applicant may ask any questions before and during the test. A waiver must be signed, stating that he/she will not hold the department liable for any injuries while performing the agility test. Each station will be read to the applicant. Then the applicant may begin at his own pace.

STATION 1: This station is to see if the applicant is able to follow directions and test his/her physical ability, and proper lifting.

The applicant must take six, 3” hoses from the back of the station to the front pad. Here the applicant is required to unroll all 6 hoses. After all 6 hoses are unrolled, the applicant must then reroll the hoses and place every other one onto the back of an engine.

STATION 2: This station is to see if the applicant is able to follow directions and test his/her physical ability.

The applicant must pull a 1.5” preconnect hose off an engine straight out. Once pulled out, the hose will be charged and the applicant must pull the hose toward the back of the engine and then to the front. The applicant will then help load the hose back onto the engine.

STATION 3: This station is to see if the applicant is afraid of heights and to test his/her physical ability.

A ladder will be raised to the side of the building and a tool placed on the roof at the edge. The applicant must climb the ladder to the top and return the tool back to the ground.

STATION 4: This station is to see if the applicant is claustrophobic.

The applicant will be shown how to don and doff a SCBA. Then the applicant can don the SCBA and do simple movements to get a feel how the SCBA works.

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Appendix C

Conditions Associated With Aortic Dissection [Chen et al. 1997]

Male gender
Age > 50 years
Hypertension
Connective tissue disorders (e.g. Marfan syndrome, Ehlers Danlos syndrome)
Turner syndrome
Noonan syndrome
Coarctation of the aorta
Congenital bicuspid or unicuspid aortic valve
History of cardiac surgery, particularly aortic valve surgery
Granulomatous arteritis
Syphilitic aortitis
Pregnancy
Trauma
Cocaine use
Systemic lupus
Relapsing polychondritis