



## **Fire Fighter Dies From Aortic Dissection During Shift – Massachusetts**

### **Executive Summary**

On July 8, 2013, a 37-year-old male career fire fighter (“FF”) started his 10-hour work shift at Station 5. At 1230 hours, Engine 5 responded to a medical call where the FF assisted with loading the patient into the ambulance. At 1511 hours, Engine 5 was dispatched to another medical call. As the crew gathered, the FF failed to respond to the call. The crew searched the station and found the FF inside a locked bathroom. He was unresponsive, with no pulse or respirations. Dispatch was notified as cardiopulmonary resuscitation (CPR) was begun, oxygen was administered via bag-valve-mask, and an automated external defibrillator (AED) delivered one shock. The ambulance arrived at 1521 hours and provided advanced life support. The FF was transported to the hospital’s emergency department (ED) where he was pronounced dead at 1554 hours.

The death certificate and autopsy report were completed by the state medical examiner’s office and listed “aortic dissection due to hypertensive cardiovascular disease” as the cause of death. It is unclear whether the exertion during the previous medical call (1230 hours) triggered the aortic dissection.

The following recommendations would not have prevented the FF’s death. However, NIOSH investigators offer these recommendations to address general safety and health issues and to prevent future cases of sudden cardiac death.

*Provide preplacement and annual medical evaluations to all fire fighters in accordance with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.*

*Phase in a mandatory comprehensive wellness and fitness program for fire fighters.*

*Perform an annual physical performance (physical ability) evaluation for all members.*

*Provide fire fighters with medical clearance to wear a self-contained breathing apparatus (SCBA) as part of the fire department’s medical evaluation program.*

*Conduct annual respirator fit testing.*

### **Introduction & Methods**

On July 8, 2013, a 37-year-old male career fire fighter died from a dissected aorta while on duty. NIOSH was notified of the fatality by the U.S. Fire Administration on July 9, 2013. NIOSH contacted the affected FD on July 9, 2013, to gather additional information and on October 23, 2013, to initiate the investigation. On December 9, 2013, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Prevention and Investigation Program investigated the incident.

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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. For further information, visit the program website at [www.cdc.gov/niosh/fire](http://www.cdc.gov/niosh/fire) or call toll free 1-800-CDC-INFO (1-800-232-4636).

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### **Introduction & Methods (cont.)**

During the investigation, NIOSH personnel interviewed the following people:

- Fire chief
- Deputy fire chief
- Union president
- Crew members

NIOSH personnel reviewed the following documents:

- FD standard operating procedures
- FD annual report for 2012
- Emergency medical service (ambulance) report
- Hospital ED report
- Death certificate
- Autopsy report

### **Investigative Results**

**Incident.** On July 8, 2013, the FF arrived for duty at his fire station at 0530 hours. The 10-hour shift began at 0800 hours, but the FF arrived early because he was having trouble sleeping and arose early. At approximately 0530 hours the FF washed his car. After the remainder of the crew arrived for duty (0800 hours), the crew performed station duties and smoke detector checks in their district throughout the morning. The crew drove back to the fire station and ate lunch at about 1130 hours. Weather conditions during the day included a high temperature of 84 degrees Fahrenheit and relative humidity of 67% [NOAA 2013].

At 1230 hours, Engine 5 and an ambulance were dispatched on a medical call involving a person who had fallen. The FF assisted in placing the person on a backboard and stretcher and loading her into the ambulance. Engine 5 returned to the station at 1300 hours.

A second medical call was received at 1511 hours. The captain and apparatus operator came down-stairs to the engine and prepared to respond. When the FF did not show up, the apparatus operator looked around the watch desk and the adjacent bathroom area. Not locating the FF, the apparatus operator called over the station intercom without success. He thought he heard a sound from the bathroom and tried to open the door, finding it locked. After kicking the door in, the apparatus operator found the FF unresponsive, with no pulse or respirations. The captain notified dispatch to request an ambulance (1518 hours). Crew members began CPR, administered oxygen via bag-valve-mask, and applied an AED. The AED advised to shock; one shock was administered without positive change in the FF's clinical status.

The ambulance responded, arriving on the scene at 1521 hours. Paramedics found the FF unresponsive with CPR in progress. A cardiac monitor was applied, revealing asystole (no heart beat). An intraosseous line was placed, and cardiac resuscitation medications were administered. The FF was intubated, with proper placement verified by esophageal bulb test [Neumar et al. 2010]. External cardiac pacing was attempted but was unable to elicit capture. A blood glucose test revealed a level of 22 milligrams per deciliter, and an infusion of 50% dextrose was administered with no change in clinical status. The FF was placed into the ambulance, which departed the scene at 1531 hours en route to the ED.

The ambulance arrived at the ED at 1534 hours. Inside the ED, the ED physician found proper placement of the endotracheal tube via direct laryngoscopy. Cardiac resuscitation efforts con-

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### **Investigative Results (cont.)**

tinued for 20 minutes until 1554 hours, when the attending physician pronounced the FF dead.

**Medical Findings.** The death certificate and autopsy report listed “aortic dissection due to hypertensive cardiovascular disease” as the cause of death. Cardiac findings showed an extensive descending aortic aneurysm, an enlarged heart, left ventricular hypertrophy, and moderate to severe coronary artery disease (Appendix A).

The FF did not complain of any chest pain prior to, or during, this episode. He was not known to have high blood pressure. His last known medical evaluation was in 2002 for his FD preplacement medical evaluation. The FD could not locate these records. The FF was 71 inches tall and weighed 232 pounds, giving him a body mass index of 32.4 kilograms per meters squared [CDC 2011].

### **Description of the Fire Department**

At the time of the NIOSH investigation, the FD consisted of eight fire stations with 192 career uniformed personnel. The FD served 96,000 residents in a geographic area of 16 square miles. In 2012, the FD responded to 9,055 incidents: 622 fire calls, 5,351 rescue/emergency medical calls, and 3,082 other calls including hazardous conditions, false alarms, and service calls.

**Membership and Training.** The FD requires career fire fighter applicants to be 18 years of age; be a high school graduate or have the equivalent certificate; have a valid state driver’s license; and pass a background check, an interview, and a candidate physical ability test (Appendix B) prior to a conditional job offer. The new hire must then pass a preplacement medical evaluation (contents

described below), a physical aptitude test, and a psychological evaluation. The new member then begins the 12-week fire training academy to become trained as a fire fighter II. Many new hires also are trained as emergency medical technicians. New members work two 10-hour day shifts (0800–1800 hours), are off duty for 24 hours, work two 14-hour night shifts (1800–0800 hours), then are off duty for 3 days. The FF was certified as a fire fighter II, emergency medical technician, first responder, and in hazardous materials. He had 11 years of fire fighting experience.

### **Preplacement and Periodic Medical Evaluations.**

The FD requires pre-placement medical evaluations for all applicants. Components of this evaluation include the following:

- Complete medical history
- Physical examination (including vital signs – height, weight, blood pressure, pulse, and respirations)
- Vision test (acuity, color, peripheral fields, and depth perception)
- Hearing test
- Drug test on hair samples

The medical evaluations are performed by a city-contracted physician. Once this evaluation is complete, the physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the FD. The FF had a preplacement medical evaluation when he was hired in 2002.

Neither periodic (annual) medical evaluation nor medical clearance to wear a respirator is required. Annual SCBA facepiece fit tests are not required. Members injured on duty or who become ill and

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### **Description of the FD (cont.)**

miss work must be evaluated by the city-contracted physician who forwards his or her determination for return-to-duty to the FD. Members who have an illness or temporary disability and miss four consecutive tours or 10 days per year must be evaluated by their primary care physician. The primary care providers forward their opinion regarding return-to-duty to the city-contracted physician who makes the final determination regarding return to work.

**Health and Wellness Programs.** The FD has a voluntary wellness/fitness program, and exercise equipment is available in the fire stations. An annual job performance physical ability test is not required for members. The FF did not participate in the fitness/wellness program.

### **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 2008; AHA 2014a]. Blood expelled from the heart under high pressure (systole) pushes more blood inside the artery wall, further splitting (dissecting) the aorta. Aortic dissection is distinguished from an aortic aneurysm, which is an expansion of the blood vessel due to medial weakening [Chen et al. 1997]. Dissections can occur in the absence of aneurysms, and not all aneurysms result in dissection. Risk factors for aortic dissection are listed in Appendix C. The FF was not known to have any of these risk factors.

Typical presentation for aortic dissection is the sudden onset of severe chest pain radiating to the back frequently associated with sweating [Chen et al. 1997; Klompas 2002; Januzzi et al. 2004; Creager and Loscalzo 2008; AHA 2014a]. 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 stethoscope.

The FF did not express specific symptoms, only stating that he could not sleep the night before. Given the lack of symptoms, it is very unlikely the FF had a partial aortic dissection prior to this incident. It is unclear if responding to the emergency medical call earlier in the day (causing an acute elevation in blood pressure) initiated or exacerbated the tear of the aorta, resulting in the dissection and his subsequent death.

### **Atherosclerotic Coronary Heart Disease.**

The FF had moderate to severe coronary heart disease on autopsy. Risk factors for its development include age older than 45, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes [NHLBI 2012; AHA 2014b]. The FF was not known to have any of these modifiable coronary heart disease risk factors, but nonetheless, had coronary heart disease.

**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



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### **Discussion (cont.)**

1582, Standard on Comprehensive Occupational Medical Program for Fire Departments [NFPA 2013a]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. Even if the FD was conducting annual medical evaluations as recommended by NFPA 1582, it is unlikely this FF's underlying coronary heart disease or his aortic dissection would have been identified.

### **Recommendations**

The following recommendations would not have prevented the FF's death. However, NIOSH investigators offer the recommendations to address general safety and health issues and to prevent future cases of sudden cardiac death.

***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.***

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 performed to determine fire fighters' medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. Although the FD is following most of the components of NFPA 1582, it does not do blood laboratory tests, spirometry, or stress tests for fire fighters at increased risk of coronary heart disease.

Fully applying NFPA 1582 involves economic repercussions and may be particularly difficult for smaller fire departments to implement. The FD is not legally required to follow the NFPA standard or the IAFF/IAFC guideline.

To overcome the financial obstacle of medical evaluations, the FD could urge current members to get annual medical clearances from their private physicians. Another option is having the annual medical evaluations completed by paramedics and emergency medical technicians from the local ambulance service (vital signs, height, weight, visual acuity, and EKG). This information could then be provided to a community physician (perhaps volunteering his or her time), who could review the data and provide medical clearance (or further evaluation, if needed). The more extensive portions of the medical evaluations could be performed by a private physician at the fire fighter's expense (personal or through insurance), provided by a physician volunteer, or paid for by the FD, city, or state. Sharing the financial responsibility for these evaluations between fire fighters, the FD, the city, the state, and physician volunteers may reduce the negative financial impact on recruiting and retaining needed fire fighters.

***Recommendation #2: Phase in a mandatory comprehensive wellness and fitness program for fire fighters.***

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, the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, and in Firefighter Fitness: A Health and Wellness Guide [IAFF, IAFC 2008; NFPA

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### **Recommendations (cont.)**

2008; Schneider 2010]. 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 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 2013].

The FD has a voluntary wellness/fitness program, and exercise equipment is available in the fire stations. NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program.

#### ***Recommendation #3: Perform an annual physical performance (physical ability) evaluation.***

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires the FD 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]. This requirement could be incorporated into the annual task-level training program.

#### ***Recommendation #4: Provide fire fighters with medical clearance to wear SCBA as part of the fire department's medical evaluation program.***

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 public employees in states operating OSHA-approved state plans. Massachusetts does not operate an OSHA-approved state plan; therefore the FD is not required to ensure all members have been medically cleared to wear an SCBA [OSHA 2013]. However, we recommend voluntary compliance with this recommendation to improve fire fighter health and safety.

#### ***Recommendation #5: Conduct annual respirator fit testing.***

The OSHA respiratory protection standard requires employers whose employees are required to use a respirator (e.g., an SCBA) to have a formal respiratory protection program, including annual fit testing [29 CFR 1910.134]. Therefore, members should have their own SCBA facepiece, or the FD would have to ensure enough facepieces of each size were made available on each fire apparatus. As mentioned previously, Massachusetts does not operate an OSHA-approved state plan; therefore, the FD is not required to follow OSHA standards [OSHA 2013]. Nevertheless, NIOSH investigators recommend voluntary compliance with this standard to ensure proper fitting personal protective equipment to improve safety and health.

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### **Investigator Information**

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component in Cincinnati, Ohio. Mr. Tommy Baldwin (MS) led the investigation and co-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 Chief and Emergency Medical Technician. Dr. Thomas Hales (MD, MPH) provided medical consultation and co-authored 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**

#### **Autopsy Findings**

- Aortic dissection extending from ascending aorta to mid-thoracic region
- Hypertensive heart disease
  - Cardiomegaly (enlarged heart; heart weighed 550 grams [g]; predicted normal weight is 403 g [ranges between 305 g and 531 g as a function of sex, age, and body weight]) [Silver and Silver 2001]
  - Left ventricular hypertrophy
    - Left ventricle thickened (1.5 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]
- Coronary artery atherosclerosis
  - Severe (75%) focal narrowing of the left anterior descending coronary artery
  - Moderate (50%) focal narrowing of the right coronary artery
  - Moderate (50%) focal narrowing of the left circumflex coronary artery
  - No definitive 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**

#### **Candidate Physical Ability Test**

1. Stair climber machine while wearing 40-pound weighted vest for 10 minutes. Pass/fail.
2. Maze rescue within 5 minutes. Pass/fail.
3. Pull ceiling prop. Using a pike pole, imitate pulling a ceiling 10 times. Pass/fail.
4. Drag 1¾-inch uncharged hoseline through the U-shaped maze. Pass/fail.
5. Manikin drag. Drag the 165-pound manikin 75 feet. Pass/fail.
6. Ladder extension. Given a 24-foot aluminum extension ladder in a securely supported vertical position, completely extend the ladder's fly section (top section). The candidate must then lower the fly section in a controlled fashion to the starting position.
7. Kaiser sled. Use the sledge hammer to strike the weighted "sled" section of the Kaiser machine a minimum of 10 times.

### **Appendix C**

#### **Risk Factors for 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