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Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

A summary of a NIOSH fire fighter fatality investigation *November, 2010*

Fire Fighter/Paramedic Dies from Aortic Dissection After Three Emergency Responses– Ohio

Executive Summary

On February 27, 2009, a 45-year-old male career Fire Fighter/Paramedic (FF/P) responded to two medical calls and a fire alarm during the morning of his shift. At lunchtime, the FF/P did not eat and retired to the upstairs bunkroom because he did not feel well. The crew was dispatched to a structure fire 3.5 hours later. As his crew prepared to respond, the FF/P was found unconscious on the bathroom floor. Cardiopulmonary resuscitation (CPR) did not revive the FF/P. The death certificate and the autopsy listed the cause of death as "cardiac tamponade due to aortic dissection due to hypertensive cardiovascular disease." NIOSH investigators agree with these conclusions.

NIOSH investigators offer the following recommendations to address general safety and health issues. However, it is unclear if these recommended programs could have prevented the FF/P's death.

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.

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

Perform an annual physical performance (physical ability) evaluation.

Introduction & Methods

On the morning of February 27, 2009, a 45-year-old male career FF/P responded to three emergency calls. He subsequently retired to the bunkroom because he was not feeling well. The FF/P was found unconscious on the bathroom floor of the fire station 3.5 hours later. Resuscitation efforts were unsuccessful. The U.S. Fire Administration notified NIOSH of this fatality on March 2, 2009. NIOSH contacted the affected fire department (FD) to gather additional information on March 30, 2009, and on July 26, 2010, to initiate the investigation. On August 2, 2010, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team conducted an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- FD Internal Affairs officers
- FD Administrative Assistant
- FD Employee Assistance Program officer
- International Association of Fire Fighters (IAFF)
- Local President
- FD physician
- The FF/P's spouse
- Crew members

NIOSH personnel reviewed the following documents:

- FD policies and operating guidelines
- FD training records
- FD annual report for 2009
- FD incident reports

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Introduction & Methods (cont.)

- Witness statements
- Ambulance report
- Death certificate
- Autopsy report
- Primary care physician records

Investigative Results

Incident. On February 27, 2009, the FF/P arrived for his 24-hour shift at Station 14 (Engine 14) at 0700 hours. Two fire fighters and a lieutenant were on duty with the FF/P. At that time he exhibited no signs or symptoms of medical problems. The crew checked out the engine and equipment and cleaned the station. At 0900 hours, the crew began a table-top training exercise on completing emergency medical reports and driving.

At 0907 hours, Engine 14 was dispatched to an emergency medical call for a seizure patient at the airport. After providing treatment and transport, Engine 14 returned to service at 0931 hours. At 0937 hours, Engine 14 was dispatched to an emergency medical call for an unconscious person. The FF/P provided medical treatment on the scene and during transport to the hospital. The crew returned to service at 1024 hours.

At approximately 1205 hours, a crew member alerted the crew that lunch was ready. The FF/P, who was upstairs in the bunkroom, did not come down to eat. The crew member walked to the bottom of the stairs (1210 hours) and called out to the FF/P, who responded "okay" but did not come downstairs. At 1238 hours, Engine 14 was dispatched to a vehicle fire. After the crew donned their gear, but before they left the station, the call was cancelled. At approximately 1310 hours the FF/P returned to the bunkroom upstairs saying he did not feel well.

At 1608 hours, Engine 14 was dispatched to a structure fire. The crew donned their gear, but the FF/P did not respond. A crew member called to the FF/P from the bottom of the stairs. The crew member then walked to the stair landing and called again but did not receive a response. The crew member went upstairs and looked through the rooms, but did not locate the FF/P. The crew member went downstairs and checked the rooms without success. He went upstairs again and checked the bathroom where he found the FF/P unconscious on the floor.

The FF/P was unresponsive with no pulse or respirations. The crew member then ran downstairs and alerted the crew. Dispatch was notified of a man down as the crew responded upstairs with resuscitation equipment, including oxygen equipment and

Investigative Results (cont.)

an automated external defibrillator (AED). (Dispatch cancelled Engine 14's response to the structure fire and added other FDs' engines to the call).

CPR was begun, and the AED was applied. The AED advised no shocks as oxygen was supplied by bag-valve-mask. CPR continued for approximately 2 minutes when Squad 5 (two paramedics) arrived at 1622 hours. A cardiac monitor was applied, revealing asystole (no heart beat). The FF/P was repositioned and it was noted that he had cool skin and rigor mortis of the upper extremities and mandible, signs that the FF/P had been deceased for several hours. The FD Medical Director responded to the scene and pronounced the FF/P dead at 1625 hours at which time resuscitation efforts were discontinued.

Medical Findings. The death certificate and the autopsy listed the cause of death as "cardiac tamponade due to aortic dissection due to hypertensive cardiovascular disease." Pertinent findings from the autopsy are listed in Appendix A.

The FF/P was 73 inches tall and weighed 296 pounds, giving him a body mass index of 39.0 kilograms per meters squared. A body mass index > 30.0 kilograms per meter squared is considered obese [CDC 2010]. The FF/P's risk factors for coronary artery disease included hypertension (high blood pressure), hypercholesterolemia (high blood cholesterol), and obesity. He was diagnosed with hypertension in 1997 and was prescribed blood pressure-lowering medications but his blood pressure readings remained elevated at nearly every visit to his primary care physician.

The FF/P's last medical evaluations were conducted in 2008 by his primary care physician and in June 2008 by his cardiologist. Cardiac examination revealed a II/VI systolic murmur. His electrocardiogram (EKG) showed normal sinus rhythm with possible left atrial abnormality, left axis deviation, left ventricular hypertrophy (LVH), and left atrial hypertrophy. An echocardiogram revealed moderate concentric LVH, mild aortic and mitral regurgitation, mild diastolic dysfunction, and mild tricuspid insufficiency. These findings are consistent with longstanding hypertension. The FF/P was scheduled for a follow-up appointment with his primary care physician in September 2008 but he missed that appointment. Prior to this incident, the FF/P never reported episodes of shortness of breath on exertion, angina, palpitations, or any other cardiac problems to his family or the FD. The day before this incident, however, the FF/P reported not feeling well.

Description of the Fire Department

At the time of the NIOSH investigation, the FD consisted of 17 fire stations with 492 uniformed career personnel that served a population of 316,000 residents in a geographic area of 88 square miles. In 2009, the FD responded to 104,764 calls: 20,140 fire calls and 84,624 medical calls. Engine 14 responded to 1,732 calls: 324 fire calls and 1,408 medical calls.

Employment and Training. The FD requires all fire fighter candidates to be between 18 and 34 years of age, have a high school diploma or General Education Diploma , and pass a general aptitude test. The FD ranks the applicants based on their scores. The applicant must pass a background check, an oral interview, a preplacement medical evaluation (described below), and a physical ability test (First Encounter Ability Test) prior to being hired. The new hire must pass the 240-hour fire academy to be trained to the Ohio Fire Fighter 2 and National Reg-

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Description of the FD (cont.)

istry Emergency Medical Technician – Basic levels. New members are assigned to a fire station where they work 24 hours on duty and 48 hours off duty. New members are on probation for a year. The FF/P was certified as a Fire Fighter II, Paramedic, Driver/Operator, Paramedic Instructor, and Fire Inspector. He had 24 years of fire fighting experience.

Preplacement Medical Evaluation. A preplacement medical examination is required by this FD for all applicants. The contents of the examination are as follows:

- Complete medical and occupational history
- Height, weight, and vital signs
- Physical examination
- Blood tests: complete blood count, lipid panel
- Urine test: urinalysis
- Chest x-ray
- Audiometry
- Vision test

These evaluations are performed by a physician under contract to the City. 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/P passed a preplacement medical evaluation (State police and fire pension system) when he was hired in 1985, but records were not available to NIOSH at the time of this report.

Periodic Medical Evaluations. Annual medical evaluations are required for hazardous materials (hazmat) operations-level responders. The contents of the examination are the same as the preplacement medical evaluation with the following tests added: respirator medical evaluation questionnaire, pulmonary function test, blood chemistry profile, and resting EKG. These evaluations are performed by a physician under contract to the City. Once this evaluation is complete, the physician makes a determination regarding medical clearance for hazmat duties and forwards this decision to the FD.

There is no periodic medical evaluation for non-hazmat fire fighters. However, the IAFF local offers free medical evaluations every 3 years for FFs over the age of 32. In addition, the City offers an annual health fair that checks blood pressure, blood cholesterol and glucose, vision, spirometry, and body mass index.

A self-contained breathing apparatus medical evaluation is performed annually for all members. The evaluation consists of completing the Occupational Safety and Health Administration (OSHA) respiratory protection questionnaire. A City-contracted physician reviews the questionnaire and forwards the clearance-to-wear a respirator decision to the FD. An annual mask fit test is then performed.

Health and Wellness Programs. No physical agility test is required for members. The FD does have a voluntary fitness program for which exercise equipment (strength and aerobic) is available in all fire stations. However, crews are not given "protected time" (time in which a crew is taken out of service) to exercise. A nutritionist is available to provide information on foods and meals. The IAFF local works via the FD Health Plan with the YMCA to provide reduced fee memberships to FD members.

A return-to-duty medical clearance is required from the City-contracted physician for duty-related injuries. If member are ill and miss more than

Description of the FD (cont.)

two shifts, their primary care physician must clear them before they may return to work. The clearance is reviewed by the City-contracted physician. Health maintenance programs are available through the City employee assistance 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 2010]. 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 aneurysms of the aorta, which are a simple 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 B. Other than hypertension, the FF/P 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 2010]. Nonspecific signs during physical examination are differences among carotid, radial, and femoral pulses [Klompas 2002], differences in blood pressure between the two arms [Sincer and Hollander 1996; Von Kodolitsch et al. 2000]; and a murmur heard through a stethoscope.

Emergency surgical repair is the preferred treatment for ascending aortic dissections with an overall in-hospital mortality rate of 15% to 20% [Chen et al. 1997; Klompas 2002; Januzzi et al. 2004; Creager and Loscalzo 2008; AHA 2010]. Medical treatment may involve lowering the blood pressure and slowing the heart rate [Chen et al. 1997].

The FF/P did not express specific symptoms, only stating that he did not feel well in the hours before his death. The only finding suggesting that he may have had an aortic dissection was a 10 millimeters of mercury (mmHg) difference in systolic blood pressure between his left and right arms. This finding, however, which was recorded by his primary care physician on at least three readings over 9 years, is not diagnostic of an aortic dissection and, by itself, would not trigger a more definitive test (e.g., a chest CT scan or transesophageal echocardiography). Given this information and lack of symptoms, it is very unlikely the FF/P had suffered a partial aortic dissection prior to this incident. It is possible that responding to the emergency medical calls earlier in the day (causing an acute elevation in blood pressure) may have initiated or exacerbated the tear of the aorta, resulting in the dissection and his subsequent death.

Cardiac Tamponade. Cardiac tamponade is the accumulation of fluid in the pericardial space in a sufficient quantity to obstruct the inflow of blood into the heart's ventricles [Braunwald 2008]. Cardiac tamponade applies pressure from the "outside" of the heart, decreasing cardiac output. This complication may be fatal if it is not recognized and treated promptly. One of the common causes of tamponade is bleeding into the pericardial space

Discussion (cont.)

from a dissecting aneurysm, as in this case.

Occupational Medical Standards for Structural Fire Fighters. To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the NFPA developed NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments [NFPA 2007a]. This voluntary industry standard provides medical requirements for candidates and current fire fighters. The FF/P had not received an FD medical evaluation within the last 12 years. However, an abnormal EKG and a cardiac examination in 2008 by his primary care physician revealed a II/VI systolic murmur, which led to an echocardiogram that revealed long-standing damage to his heart due to hypertension (moderate concentric LVH, mild aortic and mitral regurgitation, and mild tricuspid valve insufficiency). While his valvular insufficiency was considered mild, the FF/P's history of episodic marked hypertension despite treatment (systolic > 180 mmHg or diastolic > 100 mmHg) suggested he could have been restricted from fire fighting duties [NFPA 2007a]. If the FD had been providing annual medical evaluations by a physician aware of the fire service guidelines (i.e., NFPA 1582), more aggressive treatment of his hypertension coupled with duty restrictions may have prevented his death [Chobanian et al. 2003; NFPA 2007a].

Recommendations

NIOSH investigators offer the following recommendations to address general safety and health issues. However, it is unclear if these recommended programs could have prevented the FF/P's death.

Recommendation #1: 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.

Guidance regarding the content and frequency of these 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 [NFPA 2007a; IAFF, IAFC 2008]. These guidelines help to determine fire fighters' medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. However, the FD is not legally required to follow this standard or this initiative. The FD performs an SCBA medical evaluation and mask fit test annually, however pulmonary function testing is not performed nor are the other NFPA recommended components of the medical evaluation. NFPA recommends an FD physician perform the medical evaluations. However, if a private physician performs the evaluation, the results should be reviewed by the FD physician.

The FD requires hazmat medical evaluations for hazmat team members. As part of this evaluation, the FD conducts routine chest x-rays. While these tests may be indicated for hazmat fire fighters exposed to pulmonary hazards, they should not be conducted routinely and represent an unnecessary expense for the FD.

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

Guidance for fire department wellness/fitness programs is found in NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fight-

Recommendations (cont.)

ers, the International Association of Fire Fighters/ International Association of Fire Chiefs (IAFF/ IAFC) Fire Service Joint Labor Management Wellness/Fitness Initiative, and in the Firefighter Fitness: A Health and Wellness Guide [IAFF, IAFC 2008; NFPA 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 [Stein et al. 2000; Aldana 2001]. Fire service health promotion programs have been shown to reduce coronary artery disease risk factors and improve fitness levels. Mandatory programs have shown the most benefit [Dempsey et al. 2002; Womack et al. 2005; Blevins et al. 2006]. The Oregon Health and Science University reported a savings of over $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 2007]. NIOSH recommends a formal, structured wellness/fitness program to ensure all members receive the benefits of a health promotion program. Members could submit exercise affidavits or gym attendance logs for participation rewards such as time off awards.

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

NFPA 1500 recommends FD members who engage in emergency operations be annually evaluated and certified by the FD as having met the physical performance requirements identified in paragraph 10.2.3 of the standard [NFPA 2007b]. This is recommended to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting. The physical ability test could be performed as part of the FD's annual training program.

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located 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 Heath, 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

- Cardiovascular
  - Aortic dissection (10 centimeter [cm] segment of the ascending aorta and the arch of the aorta). The ascending aorta has a 3-cm horizontal laceration above the aortic valve leaflets.
  - Cardiac tamponade (750 milliliters of blood and blood clots in the pericardial sac encasing the heart)
  - Hypertensive cardiovascular disease
    - Cardiomegaly (enlarged heart) (heart weighed 710 grams [g]; predicted normal weight is 453 g [ranges between 343 g and 598 g as a function of sex, age, and body weight]) [Silver and Silver 2001]
    - Left ventricular hypertrophy (LVH)
      Left ventricular wall and interventricular septum thickened (2.0 cm)
      normal by autopsy 0.76–0.88 cm [Colucci and Braunwald 1997];
      normal by echocardiography 0.6–1.1 cm [Armstrong and Feigenbaum 2001]
  - No atherosclerosis or stenosis in the coronary arteries
  - Microscopic examination of the heart revealed myocyte hypertrophy with foci of myocytolysis
- Normal aortic, tricuspid, and pulmonic valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)

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Appendix B

Risk Factors for Aortic Dissection [Chen et al. 1997]

Male gender age > 50 years
Hypertension
Connective tissue disorders (e.g. Marfan's syndrome, Ehlers Danlos syndrome)
Turner's syndrome
Noonan's 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