Pump Operator/Engineer Suffers Heart Attack On Duty and Later Dies - Texas

Executive Summary

On July 16, 2013, a 53-year-old male career pump operator/engineer (PO/E) was serving as Acting Lieutenant for his crew's 24-hour shift. When the shift started at 0800 hours, the PO/E put his turnout gear onto the engine and checked equipment. Twenty minutes later, the PO/E entered the office complaining of sudden shortness of breath. After the medical bag was retrieved and oxygen administered, the PO/E began having chest pain. Dispatch was notified and an ambulance was requested. Ambulance paramedics provided advanced life support on-scene and en route to the local hospital's emergency department (ED). The PO/E had a long history of coronary heart disease (CHD) with bypass surgery in 2004. In the ED, a heart attack was confirmed and cardiac catheterization revealed the occlusion of two coronary artery grafts from the 2004 surgery. One of the grafts was opened and stented, but the PO/E remained unconscious in cardiogenic shock. Six days later he was transferred to a regional tertiary care hospital for a possible heart transplant. Over the next 19 days, the PO/E's clinical condition deteriorated. On August 10, 2013, the PO/E died at 2330 hours.

The death certificate listed "multi system organ failure" due to "cardiac arrest" due to "systolic heart failure" due to "coronary artery disease" as the cause of death. No autopsy was performed. NIOSH investigators concluded that the PO/E's death was a result of his underlying CHD.

Key Recommendations

- *Provide preplacement and 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 CHD*
- *Perform exercise stress tests on fire fighters at increased risk for CHD, or those who are known to have CHD*

The following recommendations would not have prevented the PO/E's death, but NIOSH investigators include them to address general safety and health issues:

- *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*
- *Phase in a mandatory comprehensive wellness and fitness program for fire fighters*
- *Provide fire fighters with medical clearance to wear a SCBA as part of the Fire Department's medical evaluation program.*

Pump Operator/Engineer Suffers Heart Attack On Duty and Later Dies - Texas

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 or call toll free 1-800-CDC-INFO (1-800-232-4636).

Pump Operator/Engineer Suffers Heart Attack On Duty and Later Dies - Texas

Introduction

On July 16, 2013, a 53-year-old male career PO/E suffered a heart attack at the beginning of his shift and died 3 weeks later. NIOSH contacted the affected FD on August 16, 2013, to gather additional information, and on November 24, 2014, to initiate the investigation. On December 8, 2014, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Prevention and Investigation Program conducted an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:
- Fire chief
- Union local president
- Crewmembers
- Deputy State Fire Marshal

NIOSH personnel reviewed the following documents:
- FD standard operating procedures
- FD annual report for 2013
- Emergency medical service (ambulance) report
- Hospital ED records
- Regional advanced care hospital records
- Death certificate

Investigation

On July 16, 2013, the PO/E arrived for duty at about 0745 hours for his 24-hour shift at Station 2. Weather conditions included a temperature of 81 degrees Fahrenheit (°F) and relative humidity of 82%, giving a heat index of 87°F [NOAA 2013]. The PO/E did not exhibit any signs or symptoms of cardiac problems. After shift change at 0800 hours, the PO/E put his turnout gear aboard Engine 2 and inspected other equipment on the engine. At approximately 0820 hours, the PO/E walked into the office complaining of shortness of breath, and sweating heavily. After the oxygen equipment was retrieved and oxygen administered to the PO/E, he began to complain of chest pain. A blood glucose test revealed a level of 354 milligrams per deciliter (mg/dL) (normal is 70-99 mg/dL). Dispatch was notified to request an ambulance.

The ambulance arrived on scene at 0822 hours, and paramedics began advanced life support. The PO/E's blood pressure was 113/76 millimeters of mercury (mmHg), his pulse rate was 104 beats per minute initially (normal is 60-80), and he was breathing at a rate of 22 breaths per minute (normal is 12-14). Oxygen was administered via rebreather mask, and intravenous fluids were administered. A blood glucose test revealed a level of 339 mg/dL. The ambulance departed the scene at 0837 hours and arrived at the hospital's ED at 0839 hours.

Pump Operator/Engineer Suffers Heart Attack On Duty and Later Dies - Texas

The PO/E had longstanding diabetes mellitus and CHD for which coronary artery bypass surgery was performed in 2004. In the ED, an electrocardiogram (EKG) and blood tests confirmed an acute heart attack as he was becoming hypotensive. The PO/E was transferred to the intensive care unit in cardiogenic shock. At 1224 hours, the PO/E was taken to the cardiac catheterization lab where he was intubated and an intra-aortic balloon pump was placed for his hypotension (86/54 mmHg). His native coronary arteries showed severe diffuse disease (unchanged from 2004), however, two of his new coronary artery grafts showed complete occlusion. Angioplasty and stenting restored blood flow to one of the grafts (the left internal mammary artery), but the PO/E remained hypotensive with a left ventricular ejection fraction of 10-15% (normal >55%).

After 6 days of treatment and no improvement in clinical status, the PO/E was transferred to a regional hospital for advanced heart failure therapy and possible heart transplantation. Over the next 2½ weeks, the PO/E's condition deteriorated. He suffered additional heart attacks and episodes of cardiac arrest. Throughout his hospitalization he suffered anoxic injury to his brain and remained unresponsive. His poor prognosis led to a withdrawal of advanced cardiac support, and at 2330 hours on August 10, 2013, the PO/E died.

Medical Findings

The death certificate listed "multi system organ failure" due to "cardiac arrest" due to "systolic heart failure" due to "coronary artery disease" as the cause of death. No autopsy was performed.

The PO/E was 64 inches tall and weighed 165 pounds, giving him a body mass index of 28.3 kilograms per meters squared [CDC 2014]. According to medical records, the PO/E had a history of diabetes, CHD, cardiomyopathy, and smoking. In 2004, the PO/E had bypass surgery. He recovered and returned to full duty without incident. The PO/E never complained of cardiac symptoms.

Fire Department

At the time of the NIOSH investigation, the FD consisted of nine fire stations with 187 career uniformed personnel. The FD served 180,000 residents in a geographic area of 152 square miles. In 2013, the Fire Suppression Division responded to 7,238 incidents: 233 structure fire calls, 251 vegetation fire calls, 125 vehicle fire calls, 94 trash fire calls, 2,704 emergency medical assist calls, 1,300 accident calls, 732 fire alarm calls, 301 investigation calls, 1,032 welfare calls, and 466 other calls. The Emergency Medical Service Division responded to 18,258 calls including 3,139 advanced life support calls and 3,139 basic life support calls.

Employment, Training, and Experience

The FD requires new fire fighter applicants to be 18-35 years of age; have a valid state driver's license and pass a background check; and undergo an FD board review, a preplacement medical evaluation, and a drug screening prior to being hired. The new member then begins the 12-week Fire Fighter I and II and Emergency Medical Technician-Basic training (unless state-certified) and/or the 9-month

paramedic training. The PO/E was certified as a Fire Fighter II, Apparatus/Operator, Emergency Medical Technician-Basic, and in Hazardous Materials Operations. He had 19 years of fire fighting experience**.**

Preplacement Medical Evaluations

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

1) Complete medical history
2) Physical examination (including vital signs – height, weight, blood pressure, pulse, and respirations)
3) Vision test (acuity, color, peripheral fields, and depth perception)
4) Audiogram
5) EKG
6) Urine drug screen
7) Urinalysis
8) Blood tests (complete blood count)
9) Chest x-ray (baseline)
10) Purified protein derivative (PPD) test for tuberculosis
11) Functional capacity exam (contents described below)

The medical evaluation is performed by a 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 PO/E had a baseline medical evaluation when he joined the FD in 1993, but this medical record was not available to the NIOSH investigator.

Member Medical Evaluations

Periodic medical evaluations are not required for members. However, promotional medical evaluations are required with the same components as the preplacement medical evaluation except a urine drug screen is not performed. It is unclear whether the PO/E had a promotional medical evaluation when he was promoted.

Medical clearance to wear a respirator is not required. Members injured on duty or who become ill and miss 90 days of work must be evaluated by the member's primary care physician who forwards their recommendation for return-to-duty to the FD. The member must then pass a (Functional Capacity Examination (FCE) to be cleared for unrestricted duty.

Wellness/Fitness Programs and Functional Capacity Examinations

The FD has a voluntary wellness/fitness program and exercise equipment is available in the fire stations. The PO/E participated in the fitness/wellness program by walking vigorously for 30 minutes during his regular shift.

An annual physical ability test is not required, however candidates are required to complete an FCE. The FCE consists of the following components:

1. Vital signs: blood pressure standing and sitting, heart rate standing and sitting
2. Claustrophobia exam
3. Vision exam. Must be better than 20/30 corrected, or 20/100 uncorrected.
4. Step test at a rate of 22.5 steps per minute for 5 minutes. The heart rate is measured at the end of every minute until the 5 minutes are completed.
5. Kneel, crawl, squat, climb, run in place, stand still. Identify any abnormality and stop the test if needed.
6. Bilateral carry 75 pounds for 50 feet
7. Drag a 170 pound weighted box for 50 feet
8. Pull a 170 pound weighted box for 50 feet
9. Push a 170 pound weighted box for 50 feet
10. Repeat kneel, crawl, squat, climb, run in place, and stand still. Identify any abnormality and stop the test if needed.
11. Carry/wear 50 pounds with consistency
12. Walk up 75 feet of stairs (wearing gym shorts and athletic shoes)

DISCUSSION

Sudden Cardiac Events

In the United States, atherosclerotic CHD is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development include age older than 45, male gender, family history of CHD, smoking, hypertension, high blood cholesterol, diabetes, and obesity/physical inactivity [Greenland et al. 2010; NHLBI 2011; AHA 2014; NHLBI 2014a]. The PO/E had known CHD (bypass surgery in 2004) with the persistence of two modifiable CHD risk factors (smoking and diabetes mellitus).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2013]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion. Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply. This sudden blockage is primarily due to blood clots (thromboses) forming on top of atherosclerotic plaques [Libby 2013].

Establishing a recent (acute) heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes, or coronary artery thrombus. In this case, the PO/E's EKG and cardiac enzymes revealed an acute heart attack. The PO/E's acute heart attack was probably due to the acute occlusion of two of his bypass graft arteries.

Pump Operator/Engineer Suffers Heart Attack On Duty and Later Dies - Texas

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 the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. Conditions relevant for the PO/E are:

Coronary Heart Disease - The PO/E's underlying CHD was identified in 2004. NFPA 1582 states that a history of myocardial infarction, coronary artery bypass surgery, coronary angioplasty with stent placement, or similar procedures compromise the member's ability to safely perform the following essential job tasks:

(1) wearing personal protective ensemble and self-contained breathing apparatus (SCBA), performing fire fighting tasks (hoseline operations, extensive crawling, lifting and carrying heavy objects, ventilating roofs or walls using power or hand tools, forcible entry, etc.), rescue operations, and other emergency response actions under stressful conditions, including working in extremely hot or cold environments for prolonged time periods;

(2) wearing an SCBA, which includes a demand valve-type positive-pressure facepiece or high efficiency particulate air (HEPA) filter masks, which requires the ability to tolerate increased respiratory workloads;

(3) depending on the local jurisdiction, climbing six or more flights of stairs while wearing fire protective ensemble weighing at least 50 pounds or more and carrying equipment/tools weighing an additional 20 to 40 pounds;

(4) wearing fire protective ensemble that is encapsulating and insulated, which will result in significant fluid loss that frequently progresses to clinical dehydration and can elevate core temperature to levels exceeding 102.2ºF;

(5) wearing personal protective ensemble and SCBA, searching, finding, and rescue-dragging or carrying victims ranging from newborns to adults weighing over 200 pounds to safety despite hazardous conditions and low visibility;

(6) wearing personal protective ensemble and SCBA, advancing water-filled hoselines up to 2½-inches in diameter from fire apparatus to occupancy [approximately 150-feet], which can involve negotiating multiple flights of stairs, ladders, and other obstacles;

(7) unpredictable emergency requirements for prolonged periods of extreme physical exertion without benefit of warm-up, scheduled rest periods, meals, access to medication(s), or hydration;

(8) functioning as an integral component of a team, where sudden incapacitation of a member can result in mission failure or in risk of injury or death to civilians or other team members.

The physician shall report applicable job limitations to the FD if any one of the following are present:

(1) current angina pectoris even if relieved by medication

(2) persistent significant stenosis in any coronary artery (> 70 percent lumen diameter narrowing) following treatment

(3) lower than normal left ventricular ejection fraction as measured by radionuclide scan, contrast ventriculography, or echocardiography

(4) maximal exercise tolerance of less than 12 METs

(5) exercise-induced ischemia or ventricular arrhythmias observed by radionuclide stress test during an evaluation reaching a workload of at least 12 METs

(6) history of myocardial infarction, angina, or coronary artery disease with persistence of modifiable risk factor(s) for acute coronary plaque rupture (e.g., tobacco use, hypertension despite treatment or hypercholesterolemia with cholesterol greater than or equal to 180 or low density lipoproteins greater than or equal to 100 despite treatment, or glycosylated hemoglobin greater than 7 despite exercise and/or weight reduction.

According to the medical records provided to NIOSH, the PO/E was never evaluated to determine whether he fulfilled criteria (1) – (6).

Diabetes Mellitus – the PO/E had a history of diabetes mellitus although medical records were not available to the NIOSH investigator to identify when he was diagnosed and what medication, if any, he was prescribed.

NFPA 1582 provides guidance for fire department physicians to follow when treating diabetic fire fighters [NFPA 2013]. The standard states that fire fighters with diabetes mellitus that is controlled by diet, exercise, or oral hypoglycemic agents should be restricted from duty unless the member meets all of the following criteria:

(1) If on oral hypoglycemic agents, has had no episodes of severe hypoglycemia (defined as requiring assistance of another in the preceding year)

(2) Has achieved a stable blood glucose as evidenced by HA_1C level less than 8 during the prior 3-month period

(3) Has a dilated retinal exam by a qualified ophthalmologist or optometrist that shows no higher grade of diabetic retinopathy than microaneurysms

(4) Has normal renal function on the basis of a calculated creatinine clearance greater than 60 milliliters per minute and absence of proteinuria

(5) Has no autonomic or peripheral neuropathy

(6) Has normal cardiac function without evidence of myocardial ischemia on cardiac stress testing (to at least 12 METs) by EKG and cardiac imaging [NFPA 2013]

The PO/E had diabetes mellitus, and since primary care physician medical records were not available to the NIOSH investigator, it is unclear if the PO/E met any of the criteria above. Therefore, according to NFPA 1582, he should have been restricted from fire fighting duties until this information was provided to the FD physician.

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 2013]. 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. The FD is not legally required to follow the NFPA standard or the IAFF/IAFC guideline.

The current preplacement medical evaluation does not include blood testing for lipids and spirometry is not performed. For members, annual medical evaluations are only provided at the time of promotion. Following this recommendation will ensure that FD members can safely perform the essential job tasks.

Recommendation #2: Perform exercise stress tests on fire fighters at increased risk for CHD, or have known CHD.

Discussion: NFPA 1582, the IAFF/IAFC *Fire Service Joint Labor Management Wellness/Fitness Initiative*, and the ACC/AHA recommend an exercise stress test (EST) for asymptomatic male fire fighters older than 45 with one or more CHD risk factors [IAFF, IAFC 2008; Gibbons et al. 2002; NFPA 2013]. In this case, the PO/E had CHD and should have had regular EST to 12 METs to ensure his medical ability to perform essential job tasks. A symptom-limiting EST may have identified the progression of his CHD, possibly leading to additional evaluation and treatment.

Pump Operator/Engineer Suffers Heart Attack On Duty and Later Dies - Texas

The following recommendations would not have prevented the PO/E's death, but NIOSH investigators include them to address general safety and health issues:

Recommendation #3: 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: The FD currently uses the member's personal physician to clear fire fighters who miss work due to a lengthy (90 days or more) illness. Personal physicians may be unaware of the hazardous and physical demands of structural fire fighting and the guidance provided by NFPA 1582. According to NFPA 1582, the FD should have an officially designated physician who is responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty [NFPA 2013]. The physician should review job descriptions and essential job tasks required for all FD 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.

Recommendation #4: 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 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 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 [Chapman 2005; Mills et al. 2007; 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]. 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 2013].

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

Recommendation #5: Provide fire fighters with medical clearance to wear SCBA as part of the Fire Department's medical evaluation program.

Pump Operator/Engineer Suffers Heart Attack On Duty and Later Dies - Texas

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 public employees in states operating OSHA-approved state plans. Because federal OSHA rules apply in Texas [OSHA 2015], the FD is not required to ensure all members have been medically cleared to wear an SCBA. However, we recommend voluntary compliance with this recommendation to improve fire fighter health and safety.

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Pump Operator/Engineer Suffers Heart Attack On Duty and Later Dies - Texas

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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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