



Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

Executive Summary

On January 7, 2011, a 54-year-old male career Fire Apparatus Operator (FAO) participated in the Fire Department (FD) mandatory annual medical evaluation program scheduled while the FAO and his crew were on-duty. After completing several portions of the evaluation, the FAO began the exercise stress test component. After exercising for 3 minutes, 10 seconds, the FAO developed a life threatening arrhythmia (ventricular tachycardia), and the test was stopped. While being assisted to the examination table and while an ambulance was summoned, the FAO lost consciousness. Cardiopulmonary resuscitation (CPR) and advanced life support (ALS) were administered at the medical clinic, in the ambulance, and in the hospital's emergency department (ED). In the ED, the FAO regained a heart rhythm, and an electrocardiogram (EKG) showed signs consistent with a heart attack (myocardial infarction). The FAO was taken to the catheterization lab with a very low blood pressure (cardiogenic shock). A 95% blockage of one of his main coronary arteries was opened via angioplasty and a stent. While still in the catheterization lab, the FAO suffered another cardiac arrest from which he could not be revived. The death certificate and the autopsy listed "atherosclerotic cardiovascular disease" as the cause of death. Given the FAO's severe underlying heart disease, NIOSH investigators concluded that the physical exertion involved

in the exercise stress test probably triggered a heart attack resulting in the FAO's death.

NIOSH investigators offer the following recommendations to address general safety and health issues. It is unclear, however, if these recommendations would have prevented the FAO's death.

Ensure fire fighters are cleared for return to duty by a healthcare provider knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of National Fire Protection Association (NFPA) 1582.

Ensure that all members participate in the Fire Department's mandatory wellness/fitness program.

Perform an annual physical performance (physical ability) evaluation.

Notify the U.S. Food and Drug Administration (FDA) that the clinic defibrillator was not working properly.

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

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).

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

Introduction & Methods

On January 7, 2011, a 54-year-old male career FAO suffered sudden cardiac death while on duty performing an FD exercise stress test as part of a required annual physical examination. NIOSH contacted the affected FD on January 13, 2011, to gather additional information, and on February 16, 2011, to initiate the investigation. On February 28, 2011, 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
- Principal assistant to the Fire Chief
- FD workers' compensation/health administrator
- FD contracted medical clinic physician
- IAFF local business agent
- Crew members
- The FAO's spouse

NIOSH personnel reviewed the following documents:

- FD training records
- FD standard operating procedures
- FD annual report for 2010
- FD incident report
- FD medical records
- Emergency medical service (ambulance) incident report
- Hospital ED records
- Death certificate
- Autopsy report
- Primary care physician records

Investigative Results

Incident. On January 7, 2011, the FAO arrived for duty at 0700 hours for his 24-hour shift. During the shift his crew was scheduled for its mandatory annual FD medical evaluations. The medical evaluations are performed by a physician at a contracted occupational health clinic. The FAO drove his crew to the medical clinic, arriving at 0800 hours. The components of the medical evaluation (discussed in a later section of this report) are consistent with the NFPA 1582.

After the crew completed the intake forms, they rotated through various aspects of the evaluation (i.e., vision test, audiometry, spirometry, blood test, exercise stress test, etc.). While sitting in the waiting room the FAO told the staff nurse that he did not want to perform the exercise stress test because of hip and low back pain from a previous occupational injury. These conditions were being treated by a pain management clinic. The FAO called the clinic's office to obtain a waiver from the exercise stress test. Once informed that a waiver would place him on light/modified duty, the FAO decided to proceed with the exercise stress test, but did not sign the consent forms.

After the examining physician reviewed the FAO's medical history and completed the medical examination, EKG leads were attached, and the FAO began the test. During the 3 minutes of Phase I of the Bruce protocol (1.7 miles per hour at 10% elevation), a unifocal premature ventricular contraction was noted at 1 minute, 12 seconds [Sport Fitness Advisor 2011]. The FAO did not complain of cardiac-related symptoms during this phase of the test.

At the 3 minute mark, Phase II began (the treadmill elevation increased to 12% and the speed

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

Investigative Results (cont.)

increased to 2.5 miles per hour [4.1 metabolic equivalents]). Ten seconds later, the EKG revealed ventricular tachycardia (fast heart beat), and the test was stopped (1029 hours). The FAO remained conscious and alert, and was assisted to the examination table. The FAO remained conversant. His blood pressure was 90/60 millimeters of mercury (mmHg). As the front desk called an ambulance, the FAO lost consciousness.

FD crew members in the clinic, hearing the 911 call, responded and provided assistance with CPR. A clinic defibrillator was attached to the FAO, and the device was prepared to deliver a shock. When an attempt was made to defibrillate, however, the defibrillator did not respond. A second defibrillation attempt was made and, again, no discharge occurred. Apparently, the unit could not maintain a charge beyond 100 joules. FD crew members retrieved an automated external defibrillator (AED) from their apparatus (1031 hours), taking approximately 1 minute. When attached to the FAO, no shock was advised from the AED. CPR continued, and an oral airway was inserted with oxygen administered via bag-valve mask.

The ambulance arrived at 1047 hours, and a cardiac monitor was attached to the FAO. A heart rhythm of ventricular fibrillation was noted, and four shocks were administered with no change in the heart rhythm or in the FAO's clinical condition. An intravenous line was placed, and cardiac resuscitation medications were administered. The FAO was positioned onto a backboard and cot, and placed into the ambulance, which departed the scene at 1103 hours en route to the hospital's ED. During transport, an additional shock was administered with no positive change in the FAO's clinical condition.

At 1108 hours the ambulance arrived at the ED, where ALS continued. The FAO was intubated, and over the next 35 minutes his heart rhythm alternated between asystole (no heart beat), pulseless electrical activity, and ventricular fibrillation for which a total of five shocks were administered. At 1145 hours, the FAO's heart rhythm was restored, and an EKG revealed a new ST-segment elevation in the anterior leads, which is indicative of an acute myocardial infarction (heart attack). An echocardiogram revealed a mildly dilated left ventricle with normal wall thickness and severe global hypokinesis (due to the heart attack). His cardiac enzymes were elevated (creatinine kinase: 315 units per liter [normal is 26–308], CKMB: 15.8 [normal is 0.0–3.2], and troponin I: 1.32 nanograms per milliliter [normal is 0.00–0.07]), suggesting the FAO had suffered a heart attack at least 24 hours earlier. His left ventricular ejection fraction was about 5% (normal is typically > 50%), and a decision was made to perform an emergent cardiac catheterization.

At approximately noon, the FAO was moved into the catheterization lab where his coronary arteries showed the following blockages: 95% occlusion in the left anterior descending coronary artery, 60% occlusion in the diagonal ostia, and a 50% occlusion in the left circumflex coronary artery. Angioplasty followed by stent placement in the left anterior descending artery occurred at 1236 hours. Shortly after the stent placement, the FAO suffered another cardiac arrest. Despite resuscitation efforts inside the catheterization lab for over 45 minutes, including the placement of a pacemaker and intra-aortic balloon pump, the FAO died. Resuscitation efforts were discontinued at 1325 hours.

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

Investigative Results (cont.)

Medical Findings. The death certificate and the autopsy listed “atherosclerotic cardiovascular disease” as the cause of death. Autopsy findings included the presence of coronary artery disease (CAD), but also microscopic (histologic) evidence of a transmural heart attack about 7–10 days prior to this episode. Specific findings from the autopsy are listed in Appendix A.

The FAO’s risk factors for CAD included obesity (body mass index of 37.5 kilograms per meters squared), hypertension (high blood pressure diagnosed and on treatment since 2009 with good control), and intermittent elevated blood cholesterol. The FAO’s elevated cholesterol levels were first identified in 2002 (total cholesterol 223 milligrams per deciliter (mg/dL). Over the subsequent 10 years his total cholesterol levels ranged from 177 to 228 mg/dL (reference values=100-199 mg/dL). His LDL or “bad” cholesterol was consistently elevated with values ranging from 100-141 mg/dL (reference values \leq 99 mg/dL). Finally, his HDL or “good” cholesterol was also consistently elevated with values ranging from 61-85 (“normal” reference values $>$ 39 mg/dL).

The FAO had been injured in a work-related accident in 1979 and suffered from persistent hip and low back pain. He was recently prescribed narcotics for his moderate to severe pain, but he chose not to take the medication because of job restrictions associated with its use. The FAO was also diagnosed with obstructive sleep apnea and had successfully used a continuous positive airway pressure machine since 2002.

In August 2010, the FAO was hospitalized for radiating chest pain occurring at rest at 6:15 in the morning. The EKGs did not suggest a heart at-

tack. Serial measurements of the cardiac enzyme troponin (a blood test used to confirm heart attacks by rising 4-8 hours after the onset of chest pain and persisting for 5-9 days) were:

- $<$ 0.4 nanograms per milliliter (ng/ml) at 0750 hours,
- 1.0 ng/ml at 1200 hours,
- 1.0 ng/ml at 1310 hours,
- $<$ 0.4 ng/ml at 1925 hours, and
- $<$ 0.4 ng/ml at 2105 hours.

Reference values for the testing laboratory were \leq 0.4=unlikely to be an acute heart attack, 0.5-1.4 =inconclusive, and \geq 1.5=probable for an acute heart attack. Subsequent testing included an echocardiogram exercise stress test. The FAO exercised for 6 minutes, 41 seconds on the Bruce protocol, achieving a maximum heart rate of 145 beats per minute (86% of age-predicted maximum heart rate of 167 beats per minute) and 6.3 metabolic equivalents (METs) with no ischemia or arrhythmias on EKG, no angina, and a normal blood pressure response. A diagnosis of atypical chest pain was made with false positive troponin level. The FAO was released and returned to full duty after missing one shift. Follow-up two weeks later by his primary care provider elicited a history of intermittent chest pain relieved by belching. A diagnosis of gastroesophageal reflux disease (GERD) (i.e. heartburn) was made and a proton pump inhibitor was prescribed. It is important to note that medical records from this hospitalization or subsequent visits with his primary care physician were not shared with the FD physician.

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

Description of the Fire Department

At the time of the NIOSH investigation, the FD consisted of 34 fire stations with 940 career uniformed fire suppression personnel and an additional 250 uniformed career EMS providers. It served 447,000 residents in a geographic area of 314 square miles. In 2010, the FD responded to 93,020 total calls of which 2,093 were fire-related incidents, 56,770 were emergency medical calls, 1,334 were HazMat events, 2,790 were rescue encounters, with the balance representing a range of other call types.

Membership and Training. The FD requires new full-time fire fighter applicants to be 18 years of age; be a high school graduate or have a GED; have a valid State driver's license; complete an initial orientation program; and pass a written test, an oral interview, and a background check. Candidates are then ranked. The top ranked candidates receive conditional offers of employment as recruit classes are formed from a pre-established eligible list. The candidate must then pass a preplacement medical evaluation (described below) prior to being hired. Recruit fire fighters attend a 16-week training academy. The first 8 weeks are devoted primarily to EMS training and preparing for the candidate physical ability test. At 8 weeks recruits must pass the candidate physical ability test to continue in the academy. The final 8 weeks are devoted to fire fighting training and emergency medical technician certification.

Recruits must also pass a second medical screening prior to entering full employment. Following graduation from the academy, probationary fire fighters have a 12-week field apprenticeship during which they rotate through several differing field placements before bid-

ding for their first field assignment. The new hire is placed on a shift working 24 hours on-duty and 48 hours off-duty, 0700 hours to 0700 hours. The FAO was certified as a Fire Fighter 2, Fire Apparatus Operator, EMT, and in hazardous materials awareness. He had 33 years of fire fighting experience.

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

- Complete medical history
- Physical examination (including vital signs)
- Complete blood count with lipid panel
- Pulmonary function test
- Resting EKG
- Exercise stress test
- Chest x-ray (baseline)
- Urinalysis
- Audiogram
- Vision screen
- Tuberculosis skin test
- Vaccinations as necessary

These evaluations are performed by an occupational medicine clinic under the supervision of a FD physician (contractor). Once this evaluation is complete, the FD physician makes a determination regarding medical clearance for wearing a respirator and fire fighting duties and forwards this decision to the FD.

Periodic Medical Evaluations. Consistent with NFPA 1582, the FD requires annual medical evaluations for all members. The components of this medical evaluation are the same as the preplacement medical evaluation except

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

Description of the FD (cont.)

chest x-rays are performed as clinically indicated. These medical evaluations are performed by the same occupational medicine clinic. Once this evaluation is complete, the FD physician makes a determination regarding medical clearance for wearing a respirator and fire fighting duties and forwards this decision to the FD. An annual SCBA medical clearance and an annual SCBA facepiece fit test are required. Members injured on duty must be evaluated by the FD physician, who makes the final determination regarding return to duty.

Health and Wellness Programs. All fire fighters receive an annual fitness evaluation (physical ability test) and an individualized fitness prescription developed by a fitness trainer and supported by a cadre of peer-fitness trainers. Exercise equipment is available in the fire stations, and fire fighters can exercise on duty, but exercise time is not protected (e.g., the fire fighter is not taken out of service). Fire fighters also have access to fitness centers for use off-duty. Participation in all FD exercise programs is voluntary; the FAO did not participate.

Discussion

Atherosclerotic Coronary Artery Disease. In the United States, atherosclerotic CAD 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 CAD, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes [NHLBI 2009; AHA 2011]. The FAO had five CAD risk factors (age over 45, male gender, hypertension, hypercholesterolemia, and obesity/physical inactivity). His risk of a heart attack or a cardiac death within the next 10 years was estimated to be 5% [NCEP 2011]. At autopsy, the FAO was found to have severe CAD.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2008]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion [Shah 1997]. 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 [Fuster et al. 1992]. This sudden blockage is primarily due to blood clots (thromboses) forming on top of atherosclerotic plaques.

The FAO had an acute heart attack confirmed by EKG, but his cardiac enzymes and autopsy also confirmed an asymptomatic (silent) heart attack 7–10 days earlier. These histologic changes were surprising because the FAO reported no recent episodes of chest pain (angina). A lack of chest pain, however, does not rule out a heart attack because in up to 20% of individuals the first evidence of CAD may be myocardial infarction or sudden death [Thaulow et al. 1993; Libby 2008].

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

Discussion (cont.)

The autopsy also revealed histologic changes (transmural and focal replacement fibrosis) indicative of an older heart attack, possibly at the time of his hospitalization for chest pain in 2010. At the time of his follow-up physician visit in August 2010 these episodes of chest pain were attributed to heartburn. It is possible his heartburn represented angina. Also confusing were the absence of EKG changes associated with the older event (August 2010) and the recent event (7–10 days earlier).

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks and sudden cardiac death [Siscovick et al. 1984; Tofler et al. 1992; Mittleman et al. 1993; Willich et al. 1993; Albert et al. 2000]. Heart attacks in fire fighters have been associated with alarm response, fire suppression, and heavy exertion during training (including physical fitness training) [Kales et al. 2003; Kales et al. 2007; NIOSH 2007]. The FAO exercised for 3 minutes, 10 seconds on an exercise stress test expending about 4.1 METs, which is considered light physical activity [AIHA 1971; Haskell et al. 1989; Giri et al. 1999]. It is not known what level of physical exertion, if any, occurred 7–10 days prior to this episode. Given the FAO's severe underlying CAD and his autopsy findings of one remote and one recent "silent" myocardial infarction, NIOSH investigators concluded that the physical exertion involved in performing the exercise stress test probably triggered a third heart attack leading to his death.

Occupational Medical Standards for Structural Fire Fighters and Exercise Stress Tests. 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 (1) the components of a preplacement and annual medical evaluation and (2) medical fitness for duty criteria. The FAO had two conditions related to decisions about medical clearance for duty.

In 2002 the FAO was found to have severe obstructive sleep apnea and was prescribed a continuous positive airway pressure unit. This did not result in any work restrictions nor did it interfere with his job performance. The NFPA cautions that obstructive sleep apnea that leads to hypoxemia (decrease in oxygen saturation) or hypercapnic disorder (elevated carbon dioxide with serum $PCO_2 \geq 45$ millimeters of mercury) compromises a member's ability to safely perform fire fighting tasks, wear a self-contained breathing apparatus, climb stairs while wearing fire protective ensemble, wear a fire protective ensemble, advance charged hoselines, and function as an integral component of a team. Although obstructive sleep apnea increases the risk of sudden cardiac events, given the FAO's successful treatment for sleep apnea, we agree with the FD physicians that the FAO's sleep apnea alone was not serious enough to result in job restrictions [Ancoli-Israel et al. 2008].

The second condition, hypertension, was first identified in 2007. In 2009 the FAO was prescribed an antihypertensive medication with subsequent good control. During the FAO's hospitalization for atypical chest pain in August 2010, he was discharged on a beta-adrenergic blocker rather than his usual antihypertensive agent. This change in medication was not communicated to the FD physician. The NFPA considers use of beta-blockers to potentially preclude safely wearing the fire protective ensemble and safely climbing ladders, operating from heights, walking or crawling in the dark along narrow and uneven surfaces, and operating near electrical power

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

Discussion (cont.)

lines and/or other hazards because of the risk for dehydration, electrolyte disorders, lethargy, and disequilibrium [NFPA 2007a]. Shortly after discharge, however, the beta-adrenergic blocker was stopped in favor of his original antihypertensive medication.

During FD medical evaluations in September 2004, July 2006, December 2007, and January 2009 the FAO performed exercise stress tests according to NFPA 1582 protocols. NFPA 1582 recommends an exercise stress test performed “as clinically indicated by history or symptoms” and refers the reader to Appendix A [NFPA 2007a]. Items in Appendix A are not standard requirements, but are provided for “informational purposes only.” Appendix A recommends using submaximal (85% of predicted heart rate) stress tests as a screening tool to evaluate a fire fighter’s aerobic capacity. Maximal (e.g., symptom-limiting) stress tests with imaging should be used for fire fighters with the following conditions:

- abnormal screening submaximal tests
- cardiac symptoms
- known coronary artery disease
- two or more risk factors for CAD (in men older than 45 and women older than 55)

Risk factors are defined as hypercholesterolemia (total cholesterol greater than 240 milligrams per deciliter), hypertension (diastolic blood pressure greater than 90 mm of mercury), smoking, diabetes mellitus, or family history of premature CAD (heart attack or sudden cardiac death in a first-degree relative less than 60 years old).

Since the FD had adopted, and the medical clinic was following NFPA 1582, the FD performed screening submaximal stress tests to evaluate aerobic capacity. From 2004 to 2009 the FAO’s aerobic capacity was estimated to be 7.1 METs. Although the stress test showed no signs of isch-

emic heart disease (no angina, no EKG changes, no arrhythmias, and normal blood pressure response), this relatively low aerobic capacity suggests the FAO may have been unable to perform all essential tasks of a structural fire fighter [Sothmann et al. 1990; Gledhill et al. 1992]. At this time, however, NFPA does not recommend a minimum aerobic capacity unless the fire fighter has known CAD [NFPA 1582]. The FAO did not have known CAD, nor did he have NFPA 1582 criteria recommending a diagnostic exercise stress test.

It is important to note that several organizations have published guidelines on exercise stress tests for asymptomatic individuals that differ from the NFPA. One organization is the American College of Cardiology/American Heart Association (ACC/AHA)[Gibbons et al. 2002]. The ACC/AHA guideline states exercise testing in asymptomatic people could be considered for the following groups based on “Class IIB” evidence (“less well established”):

- persons with multiple risk factors (defined similarly to those listed by the NFPA)
- asymptomatic men older than 45 years and women older than 55 years:
 - who are sedentary and plan to start vigorous exercise
 - who are involved in occupations in which impairment might jeopardize public safety (e.g., fire fighters)
 - who are at high risk for coronary artery disease due to other diseases (e.g., peripheral vascular disease and chronic renal failure)

The U.S. Department of Transportation provides guidance for those seeking medical certification for a commercial drivers’ license. An expert medical panel recommended exercise tolerance tests (stress tests) for asymptomatic “high risk” drivers [Blumenthal et

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

Discussion (cont.)

al. 2007]. The panel defines high risk drivers as those with any of the following:

- diabetes mellitus
- peripheral vascular disease
- age 45 and above with multiple risk factors for coronary heart disease
- Framingham risk score predicting a 20% coronary heart disease event risk over the next 10 years

The U.S. Preventive Services Task Force (USPSTF) does not recommend stress tests for asymptomatic individuals at low risk for coronary heart disease events. For individuals at increased risk for coronary heart disease events, the USPSTF found “insufficient evidence to recommend for or against routine screening with EKG, exercise tolerance test, or electron beam computerized tomography scanning...” Rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes) [USPSTF 2004]. The USPSTF does note that “For people in certain occupations, such as pilots, and heavy equipment operators (for whom sudden incapacitation or sudden death may endanger the safety of others), consideration other than the health benefit to the individual patient may influence the decision to screen for coronary heart disease.”

The FAO had elevated cholesterol. The FD clinic appropriately counseled the FAO regarding diet, exercise, and weight loss. The clinic, also appropriately, did not recommend cholesterol reducing medications per national guidelines [NHLBI 2002]. In addition, as mentioned above, the total cholesterol levels were not high enough (e.g. ≥ 240 mg/dL) to trigger a maximal or diagnostic stress tests per NFPA 1582 criteria [NFPA 2007a].

Recommendations

NIOSH investigators offer the following recommendations to address general safety and health issues. It is unclear, however, if these recommended programs would have prevented the FAO’s death.

Recommendation #1: Ensure that fire fighters are cleared for return to duty by a healthcare provider knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

The FAO was hospitalized for radiating chest pain in August 2010 and was diagnosed with atypical chest pain with a falsely elevated troponin level. His evaluation included an exercise stress test in which he achieved only 6.3 METs. The typical workload of a structural fire fighter is somewhere between 10-12 METs [Sothmann et al. 1990; Gledhill and Jamnik 1992]. His cardiologist agreed with the diagnosis, and the FAO was given a return to work clearance. However, the FD-contracted occupational medicine clinic did not evaluate the clearance. Even though the FAO continued to work with no further cardiac-related symptoms, the FD-contracted occupational medicine clinic should have reviewed the clearance.

Recommendation #2: Ensure that all members participate in the Fire Department’s mandatory wellness/fitness program.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Physical inactivity, or lack of exercise, is associated with other risk factors, including obesity and diabetes [Plowman and Smith 1997]. While the FD had a written mandatory wellness/fitness pro-

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

Recommendations (cont.)

gram, compliance with the policy was not universally applied. We encourage the FD to review this program to ensure 100% participation. Guidance for implementation and components of a wellness/fitness program are found in NFPA 1583, in the IAFF/IAFC's Fire Service Joint Labor Management Wellness/Fitness Initiative, and NFPA 1500 [NFPA 2007b; IAFF, IAFC 2008; NFPA 2008]. 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 CAD 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 2007]. In order for all members to receive the benefits of a health promotion program, participation is necessary. Also, during exercise time, employees should be taken out of service to ensure uninterrupted participation.

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

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 2007b]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2007b]. This evaluation could be incorporated into and FD annual training plan.

Recommendation #4: Notify the U.S. Food and Drug Administration of the clinic defibrillator not working properly.

The occupational medicine clinic reported checking the defibrillator every morning and changing the batteries. After this incident, the clinic sent the defibrillator to the hospital's biomedical department who tested the unit and did not find a cause for the malfunction. Medical Device Reporting is the mechanism for the Food and Drug Administration (FDA) to receive input on medical device malfunctions [FDA 2009]. While the malfunction of the medical clinic's defibrillator did not contribute to the FF's death because of the rapid retrieval of the Engine's AED, we still recommend the clinic also notify the FDA of the incident. The FDA can then determine if other problems have been reported with this particular make and model of defibrillator and take appropriate action.

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

References

- AHA [2011]. AHA scientific position, risk factors for coronary artery disease. Dallas, TX: American Heart Association. [http://www.heart.org/HEARTORG/Conditions/HeartAttack/UnderstandYourRiskofHeartAttack/Understand-Your-Risk-of-Heart-Attack_UCM_002040_Article.jsp]. Date accessed: April 2011.
- AIHA [1971]. Ergonomics guide to assessment of metabolic and cardiac costs of physical work. *Am Ind Hyg Assoc J* 32(8):560–564.
- Albert CM, Mittleman MA, Chae CU, Lee IM, Hennekens CH, Manson JE [2000]. Triggering of sudden death from cardiac causes by vigorous exertion. *N Engl J Med* 343(19):1355–1361.
- Aldana SG [2001]. Financial impact of health promotion programs: a comprehensive review of the literature. *Am J Health Promot* 15(5):296–320.
- Ancoli-Israel S, Czeisler CA, George CFP, Guilleminault C, Pack AI [2008]. Expert panel recommendations: obstructive sleep apnea and commercial motor vehicle driver safety. Presented to Federal Motor Carrier Safety Administration January 14, 2008. [<http://www.fmcsa.dot.gov/rules-regulations/TOPICS/mep/report/Sleep-MEP-Panel-Recommendations-508.pdf>]. Date accessed: April 2011.
- Blevins JS, Bounds R, Armstrong E, Coast JR [2006]. Health and fitness programming for fire fighters: does it produce results? *Med Sci Sports Exerc* 38(5):S454.
- Blumenthal RS, Epstein AE, Kerber RE [2007]. Expert panel recommendations. Cardiovascular disease and commercial motor vehicle driver safety. [http://www.mrb.fmcsa.dot.gov/documents/CVD_Commentary.pdf]. Date accessed: April 2011.
- Dempsey WL, Stevens SR, Snell CR [2002]. Changes in physical performance and medical measures following a mandatory firefighter wellness program. *Med Sci Sports Exerc* 34(5):S258.
- FDA (Food and Drug Administration) [2009]. How to report a problem (medical devices). [<http://www.fda.gov/MedicalDevices/Safety/ReportaProblem/default.htm>]. Date accessed: April 2011.
- Fuster V, Badimon L, Badimon JJ, Chesebro JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. *N Engl J Med* 326(4):242–250.
- Gibbons RJ, Balady GJ, Bricker JT, Chaitman BR, Fletcher GF, Froelicher VF, Mark DB, McCallister BD, Mooss AN, O'Reilly MG, Winters WL Jr., Antman EM, Alpert JS, Faxon DP, Fuster V, Gregoratos G, Hiratzka LF, Jacobs AK, Russell RO, Smith SC Jr. [2002]. ACC/AHA 2002 guideline update for exercise testing: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation* 106(14):1883–1892.
- Giri S, Thompson PD, Kiernan FJ, Clive J, Fram DB, Mitchel JF, Hirst JA, McKay RG, Waters DD [1999]. Clinical and angiographic characteristics of exertion-related acute myocardial infarction. *JAMA* 282(18):1731–1736.

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

References (cont.)

- Gledhill N, Jamnik VK [1992]. Characterization of the physical demand of firefighting. *Can J Spt Sci* 17(3): 207-213.
- Haskell WL, Brachfeld N, Bruce RA, Davis PO, Dennis CA, Fox SM III, Hanson P, Leon AS [1989]. Task Force II: determination of occupational working capacity in patients with ischemic heart disease. *JACC* 14(4):1025–1034.
- IAFF, IAFC [2008]. The fire service joint labor management wellness/fitness initiative. 3rd ed. Washington, DC: International Association of Fire Fighters, International Association of Fire Chiefs.
- Kales SN, Soteriades ES, Christoudias SG, Christiani DC [2003]. Firefighters and on-duty deaths from coronary heart disease: a case control study. *Environ health: a global access science source*. 2:14. [<http://www.ehjournal.net/content/2/1/14>]. Date accessed: April 2011.
- Kales SN, Soteriades ES, Christophi CA, Christiani DC [2007]. Emergency duties and deaths from heart disease among fire fighters in the United States. *N Engl J Med* 356(12):1207–1215.
- Kuehl K [2007]. Economic impact of the wellness fitness initiative. Presentation at the 2007 John P. Redmond Symposium in Chicago, IL on October 23, 2007.
- Libby P [2008]. The pathogenesis, prevention, and treatment of atherosclerosis. In: Fauci AS, Braunwald E, Kasper DL, Hauser SL, Longo DL, Jameson JL, Loscalzo J, eds. *Harrison's principles of internal medicine*. 17th ed. New York: McGraw-Hill, pp. 1501–1509.
- Meyerburg RJ, Castellanos A [2008]. Cardiovascular collapse, cardiac arrest, and sudden cardiac death. In: Fauci AS, Braunwald E, Kasper DL, Hauser SL, Longo DL, Jameson JL, Loscalzo J, eds. *Harrison's principles of internal medicine*. 17th ed. New York: McGraw-Hill, pp. 1707–1713.
- Mittleman MA, Maclure M, Tofler GH, Sherwood JB, Goldberg RJ, Muller JE [1993]. Triggering of acute myocardial infarction by heavy physical exertion. *N Engl J Med* 329(23):1677–1683.
- NCEP [2011]. National Cholesterol Education Program (NCEP). Risk assessment tool for estimating 10-year risk of developing hard CHD (myocardial infarction and coronary death) [<http://hp2010.nhlbihin.net/atpiii/calculator.asp?usertype=prof#moreinfo>]. Date accessed: August 2011.
- NFPA [2007a]. Standard on comprehensive occupational medical program for fire departments. Quincy, MA: National Fire Protection Association. NFPA 1582.
- NFPA [2007b]. Standard on fire department occupational safety and health program. Quincy, MA: National Fire Protection Association. NFPA 1500.
- NFPA [2008]. NFPA 1583: Standard on health-related fitness programs for fire fighters. Quincy, MA: National Fire Protection Association.
- NHLBI [2002]. Third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (ATP III final report). National Heart, Lung, and Blood Institute. [http://www.nhlbi.nih.gov/guidelines/cholesterol/atp3_rpt.htm]. Date accessed: August 2011.

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

References (cont.)

- NHLBI [2009]. Who is at risk for coronary artery disease? National Heart, Lung, and Blood Institute. [<http://www.nhlbi.nih.gov/health/health-topics/topics/cad/atrisk.html>]. Date accessed: August 2011.
- NIOSH [2007]. NIOSH alert: preventing fire fighter fatalities due to heart attacks and other sudden cardiovascular events. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2007-133.
- Plowman SA, Smith DL [1997]. Exercise physiology: for health, fitness and performance. Boston, MA: Allyn and Bacon.
- Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. *Clin Cardiol* 20(11 Suppl2):II-38–44.
- Siscovick DS, Weiss NS, Fletcher RH, Lasky T [1984]. The incidence of primary cardiac arrest during vigorous exercise. *N Engl J Med* 311(14):874–877.
- Sothmann MS, Saupe KW, Jasenof D, Blaney J, Fuhrman SD, Woulfe T, Raven PB, Pawelczyk JP, Dotson CO, Landy FJ, Smith JJ, Davis OP [1990]. Advancing age and the cardiorespiratory stress of fire suppression: determining a minimum standard for aerobic fitness. *Human Performance* 3(4):217-236.
- Sport Fitness Advisor [2011]. The Bruce treadmill test. [<http://www.sport-fitness-advisor.com/bruce-treadmill-test.html>]. Date accessed: April 2011.
- Stein AD, Shakour SK, Zuidema RA [2000]. Financial incentives, participation in employer sponsored health promotion, and changes in employee health and productivity: HealthPlus health quotient program. *J Occup Environ Med* 42(12):1148–1155.
- Thaulow E, Erikssen J, Sandvik L, Erikssen G, Jorgensen L, Cohn PF [1993]. Initial clinical presentation of cardiac disease in asymptomatic men with silent myocardial ischemia and angiographically documented coronary artery disease (The Oslo Ischemia Study). *Am J Cardiol* 72(9):629–633.
- Tofler GH, Muller JE, Stone PH, Forman S, Solomon RE, Knatterud GL, Braunwald E [1992]. Modifiers of timing and possible triggers of acute myocardial infarction in the thrombolysis in myocardial infarction phase II (TIMI II) study group. *J Am Coll Cardiol* 20(5):1049–1055.
- USPSTF [2004]. U.S. Prevention Services Task Force. Screening for coronary heart disease: Recommendation Statement. *Ann Intern Med* 140(7):569–572.
- Willich SN, Lewis M, Lowel H, Arntz HR, Schubert F, Schroder R [1993]. Physical exertion as a trigger of acute myocardial infarction. *N Engl J Med* 329(23):1684–1690.
- Womack JW, Humbarger CD, Green JS, Crouse SF [2005]. Coronary artery disease risk factors in firefighters: effectiveness of a one-year voluntary health and wellness program. *Med Sci Sports Exerc* 37(5):S385.

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

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).

Fire Apparatus Operator Suffers Fatal Heart Attack During Annual Fire Department Medical Evaluation – Missouri

Appendix A

Autopsy Findings

- Atherosclerotic cardiovascular disease
 - Severe (95%) focal narrowing of the left anterior descending coronary artery
 - Moderate (60%) focal narrowing of the left diagonal coronary artery
 - Moderate (50%) focal narrowing of the left circumflex artery
 - Moderate (50%) focal narrowing of both coronary artery ostia
 - Microscopic evidence of a recent myocardial infarction (7–10 days old) as evidenced by early formation of fibrovascular granulation tissue and well developed phagocytosis of dead cells
 - Microscopic evidence of a remote myocardial infarction, perhaps from August 2010, as evidenced by transmural focal replacement fibrosis
- Cardiomegaly (enlarged heart) (heart weighed 580 grams [g]; predicted normal weight is 421 g [between 319 g and 556 g as a function of sex, age, and body weight]) [Silver and Silver 2001]
 - Left ventricular hypertrophy
 - Left ventricular wall and septum thickened (1.7 cm and 1.5 cm respectively)
 - normal by autopsy 0.76–0.88 cm [Colucci and Braunwald 1997];
 - normal by echocardiography 0.6–1.0 cm [Connolly and Oh 2012]
- Myxoid degenerative changes to the mitral valve
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Microscopic evidence of blood tests for drugs and alcohol were negative

References:

Colucci WS, Braunwald E [1997]. Pathophysiology of heart failure. In: Braunwald, ed. Heart disease. 5th ed. Philadelphia, PA: W.B. Saunders Company, p. 401.

Connolly HM, Oh JK [2012]. Echocardiography. In: Bonow RO, Mann DL, Zipes DP, Libby P, Braunwald E, eds. Heart disease: a text of cardiovascular medicine. 9th ed. Vol. 1. Philadelphia, PA: Elsevier Saunders, p. 216.

Silver MM and Silver MD [2001]. Examination of the heart and of cardiovascular specimens in surgical pathology. In: Silver MD, Gotlieb AI, Schoen FJ, eds. Cardiovascular pathology. 3rd ed. Philadelphia, PA: Churchill Livingstone, pp. 8–9.