F2000 42

NIOSH Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation *July 9, 2003*

Lieutenant Suffers a Cardiac Arrest During a Structural Drill – Kentucky

SUMMARY

On February 13, 2000, a 48-year-old male Lieutenant participated in a structural drill at a three-story barracks. After exiting the structure and walking to the Engine, he sat down on the Engine's running board, and collapsed. Despite cardiopulmonary resuscitation (CPR) and advanced life support (ALS) performed on the scene by crewmembers and paramedics, and by hospital personnel at the emergency department (ED), the victim died. The death certificate, completed by the Attending Physician, listed "hypertensive atherosclerotic cardiovascular disease" as the immediate cause of death. The autopsy report, completed by the Assistant Medical Examiner, listed "hypertensive atherosclerotic cardiovascular disease" as the cause of death and "diabetes, hyperlipidemia, tobacco use, and hypertension" as contributing factors.

The following recommendations address some general health and safety issues identified during this investigation. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These selected recommendations have not been evaluated by NIOSH, but represent published research, consensus votes of technical committees of the National Fire Protection Association (NFPA), or fire service labor/management groups. Issues relevant to this Fire Department include:

- ***Incorporate exercise stress tests into the Fire Department's periodic medical evaluation program.***
- ***Preclude from fire fighting activities those individuals with medical conditions that would present a significant risk to the safety and health of themselves or others.***
- ***Clear fire fighters for duty by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582.***
- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***
- ***Integrate all emergency services dispatching into one communication center.***
- ***Provide adequate fire fighter staffing to ensure safe operating conditions.***

INTRODUCTION AND METHODS

On February 13, 2000, a 48-year-old male Lieutenant died after suffering a cardiac arrest while performing a structural drill. On October 24, 2000,

NIOSH contacted the affected Fire Department to initiate the investigation. On November 6, 2000, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Kentucky to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed:

- The Deputy Fire Chief
- Union representative
- Crew members on duty with the victim
- Ambulance service paramedics
- The victim's wife

During the site-visit NIOSH personnel reviewed:

- Fire Department policies and operating guidelines
- Fire Department training records
- The Fire Department annual report for 1999
- Fire Department physical examination protocols
- Ambulance response report
- Hospital records
- Past medical records of deceased from private physician
- Death Certificate
- Autopsy report

INVESTIGATIVE RESULTS

Incident. On February 13, 2000, the victim reported for work at 0700 hours. The morning was spent performing equipment checks and station maintenance. At 0930 hours, a pre-briefing was given by the Acting Assistant Chief (Chief 3) to begin the structural drill. The drill would involve performing simulated fire attack in a 3-story, cinder block barracks, measuring approximately 200 feet long and approximately 60 feet wide, and involving three engine companies, one rescue company, and 15 personnel. Chief 3, Engine 1 (Driver/Operator, Captain, and two Fire Fighters), Engine 2 (Driver/Operator, Captain, and two Fire Fighters), Engine 3 (Driver/Operator [victim], Captain, and two Fire Fighters), and Rescue 1 (two Fire Fighters) notified E-911 Dispatch and became enroute to the designated structure between 0939 hours and 0942 hours. Units began to arrive on the scene at 0941 hours. Engine 3, the first-in Engine, dropped off the victim at a nearby hydrant to connect the 5-inch supply hose. Engine 3 proceeded to the structure where crew members pulled a 2½-inch hoseline into the building and wyed the line to two 1¾-inch attack lines. Two fire fighters advanced one 1¾-inch hoseline to the third floor to begin a simulated fire attack, while two other fire fighters manned the second 1¾-inch hoseline stationed at the third floor landing. Two fire fighters formed a rapid intervention team (RID) stationed outside the building. Finally, three fire fighters raised a 36-foot extension ladder to the building. No hydrant connection was requested by Chief 3, and the victim walked from the hydrant location to the building.

As the drill came to a close, the remainder of the on-scene crews, including the victim, entered the structure to participate in a debriefing on the third floor. After the debriefing, the victim exited the building, stumbled over some fire hose, walked to Engine 3, and sat on the Engine's side step. As he took his helmet off, he slumped against the side of the Engine. A Lieutenant ran over to the victim to prevent him from falling off the Engine. The Lieutenant checked the victim's pulse and level of consciousness, called Central Dispatch (0956 hours) via radio, and requested an ambulance "ASAP." He also notified Chief 3 and requested help from crew members still inside the structure. Crew members retrieved a backboard and medical equipment. After removing the victim's bunker coat, they placed him onto the backboard. Assessment of the victim revealed he was conscious but unable to speak. He had a weak pulse and was still breathing, so oxygen was administered via nonrebreather mask.

The E-911 Dispatcher picked up the direct-link telephone to the hospital operator and advised the hospital operator that the fire fighters were performing a drill and were requesting an ambulance ASAP. The Dispatcher gave the hospital operator the cross streets of the location of the drill. At 0959 hours, the ER dispatched the ambulance (Medic 102) to a "drill" and gave the location. The Captain from Engine 1 notified Central Dispatch to tell the ambulance to turn their radios to the Fire Net, which was done. The hospital operator advised Medic 102 to change their radio to the fire frequency upon approach, which was acknowledged. At 1001 hours Medic 102 (one Paramedic and one emergency medical technician [EMT]), was enroute.

After exiting the hospital grounds, Medic 102 changed their response mode to emergency (lights and siren). (Normal response to a training exercise is non-emergency mode.) The Captain from Engine 1 notified Central Dispatch to contact the hospital operator again and have their ambulance change their radio to Fire Net 1. After Medic 102 changed their radio to Fire Net 1, a second Central Dispatcher advised them to talk with Engine 1. Chief 3 then advised Medic 102 that a man was down, was receiving oxygen, and needed transport as rapidly as possible. However, Medic 102 was unsure if this was an actual emergency or part of the drill. Just prior to Medic 102's arrival, the victim's rate of breathing slowed and assisted ventilations were administered via bag-valve-mask. As the ambulance arrived at 1003 hours, the victim became pulseless.

Fire fighters advised the ambulance crew that the victim initially had a pulse, but now he was pulseless, apneic, and was receiving assisted ventilations and CPR. The ambulance crew attached a cardiac monitor to the victim at 1004 hours; it revealed pulseless electrical activity (PEA). ALS measures were initiated. A second monitor assessment revealed ventricular fibrillation, for which one electrocardioversion (shock) was delivered. After the shock, the victim's heart rhythm reverted to PEA, which continued during the entire transport period. After the victim was intubated, CPR continued as the victim was loaded into the ambulance, which departed the scene at 1016 hours. While enroute to the hospital, two attempts at intravenous access were unsuccessful. The ambulance arrived at the hospital emergency department (ED) at 1018 hours.

Inside the ED, CPR and ALS continued. A cardiac monitor revealed ventricular fibrillation and six additional shocks were administered, but no pulse was regained. Resuscitation efforts were stopped at 1045 hours, and the victim was pronounced dead by the attending physician.

Medical Findings. The death certificate, completed by the Attending Physician, listed "hypertensive atherosclerotic cardiovascular disease" as the immediate cause of death.
"Diabetes, hyperlipidemia, tobacco use, and hypertension" were listed as contributing factors.

Pertinent findings from the autopsy report, completed by the Assistant Medical Examiner, are listed below:

- Hypertensive atherosclerotic cardiovascular disease
- Cardiomegaly
- High grade stenosis (80%) of the circumflex and proximal left anterior descending arteries
- Total occlusion of the mid-left anterior descending artery
- Stent within the right coronary artery
- Acute thrombus of the right coronary artery
- Circumferential scarring of the left ventricular free wall and septum
- Peripheral vascular disease of the abdominal aorta
- Nephrosclerosis
- Diabetes mellitus

- Hyperlipidemia
- Documented history of inferior wall infarction in 1997
- "Documented history of tobacco use"
- "Documented history of hypertension"

Medical records indicated that the victim had all eight risk factors for coronary artery disease (CAD): male gender, advanced age (>45 years old), smoking, family history, high cholesterol, hypertension, diabetes, and obesity/lack of regular physical activity. The victim regularly took his prescribed anti-hypertensive medications, cholesterol lowering medications, and insulin to control his diabetes. He had not complained to anyone of chest pain or other discomfort prior to his heart attack [myocardial infarction (MI)] and sudden death.

Medical records indicated the victim suffered a heart attack (inferior wall MI) in May of 1997, treated successfully with a blood clot dissolver [tissue plasminogen activator (TPA)], and followed five days later by cardiac catheterization and stent placement in his right coronary artery. At that time his heart function was normal (left ventricular ejection fraction was 55%) despite the heart damage from his heart attack (inferior wall akinesis). The cardiac catheterization revealed a number of partial occlusions of his other coronary arteries (left anterior descending: ostial 80% lesion, distal 100% occlusion; third diagonal 60 to 70% lesion; left circumflex irregularities, and ramus ostial 60% lesion). According to medical records provided to NIOSH, he was not given an exercise stress test (EST) prior to his return to work in July of 1997.

On March 4, 1999, a routine physical examination revealed a change in his electrocardiogram (EKG) (incomplete left bundle branch block, left atrial enlargement, and left anterior hemiblock). Subsequent evaluation by his cardiologist included an EST with an imaging study and an echocardiogram on March 11,1999. The echocardiogram showed a change in his heart function (left ventricular ejection fraction of 35%, dyskinetic left ventricular apex with evidence suggestive of a laminated apical thrombus). The victim had to stop his EST after nine minutes [Stage III of the Bruce protocol - 10.6 maximal metabolic equivalents (METS)] due to fatigue and chest pressure. The electrocardiogram (EKG) was reported to not show any ischemic changes. During his EST, his systolic blood pressure raised only eight millimeters of mercury (mmHg) (120 mmHg at rest to 128 mmHg at the end of the nine minutes). The imaging test (thallium) showed his old, previously documented heart attack (inferior wall infarct) and a recent (some time between May 1997 and March 1999) large anteroapical infarct with a possible area of ischemia. A subsequent resting imaging study was conducted to ascertain if any ischemic areas remained, but the results were not available to NIOSH at the time of this report. On March 12, 1999, his cardiologist recommended to the Installation Preventive Medicine clinic that the victim be returned to full duty. This newly found MI (anteroapical infarct) was not previously identified, and was not associated with any reported chest pain.

Over the past year, the victim had not expressed any signs or symptoms of chest pain or discomfort to his wife, co-workers, or health care providers. On February 12, the day prior to the victim's sudden death, he went bowling but performed no other strenuous activities at home. On February 13, the day of his collapse, the victim reported to the Fire Department for work as usual. Throughout the morning, he participated in roll call and attended a meeting prior to the structural drill.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department consisted of 64 uniformed career

personnel and served a population of 50,000 residents in a geographic area of 180 square miles. There are four fire stations. Fire fighters, including the victim, work one of three shifts from 0700-0700 hours, and work 24 hours on duty, 24 hours off duty for six tours, then are off duty for 3 days.

In 1999, the Department responded to 1,408 calls: 32 structure fires, 19 vehicle fires, 14 wildland fires, 17 refuse fires, 1 explosion, 5 other fires, 164 aircraft/ flightline emergencies, 28 rescue calls, 232 hazardous condition/standby calls, 809 false calls, 59 good intent calls, 13 operation of fixed extinguishing system calls, 10 service calls, and 5 mutual aid (off-Installation) calls.

Training. The Fire Department requires all new fire fighters to pass a preplacement physical examination. The new fire fighter must be pre-certified to the level required by the vacant position. Subsequent training is conducted on-shift. Fire fighters certified in hazardous materials (Hazmat), CPR, and EMT are re-certified annually. The victim was certified as a Fire Officer I, EMT, Hazmat, and Airport Fire Fighter, and had 24 years of fire fighting experience. He was currently serving as a Lieutenant and a Driver/Operator.

Preplacement Evaluations. The Department requires a preplacement medical evaluation for all new hires, regardless of age. Components of this evaluation include the following:

- History
- Vital Signs
- Physical examination
- Blood tests: Complete Blood Count (CBC), Metabolic Profile, Lipid Profile, and Liver Function
- Urine Tests: Urine dip stick and Urinalysis
- Pulmonary Function Test
- Resting EKG
- Chest x-ray
- Audiometry
- Vision test: distant and near vision

These evaluations are performed by the Installation physician, who makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the Fire Department.

Periodic Evaluations.
Periodic medical evaluations are required annually by this Department. Components of this are the same as the preplacement evaluation, except a chest x-ray is not included. These evaluations are performed by the Installation physician, and the medical clearance decision for each examination is forwarded to the Fire Department. If an employee is injured at work or ill, the employee is evaluated and must be cleared for "return to work" by the Preventive Medicine clinic at the Installation. The input from the employee's private physician is considered at this point. As described earlier, the victim's last Fire Department medical examination was in March, 1999. Due to his abnormal EKG, he was placed on medical leave until an evaluation by his private cardiologist was completed. After this evaluation, his cardiologist recommended that he be returned to full duty.

All fire stations have exercise (strength and/or aerobic) equipment purchased by the Fire Department. One hour is set aside daily for mandatory fitness training, but the type of exercise is not specified. Wellness programs (smoking cessation, weight control, high blood pressure, diabetes, or cholesterol) are also offered by the Installation.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.[1] Risk

factors for its development include increasing age, male gender, family history of coronary artery disease (CAD), smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes.[2] The victim had all of these risk factors.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.[3] However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.[4] 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.[5] This sudden blockage is primarily due to blood clots (thrombosis) forming on top of atherosclerotic plaques. The victim's autopsy report identified a thrombosis in the right coronary artery and the scarring of his heart due to his previous heart attacks. The victim's second heart attack occurred sometime between July 1997 and March 1999 and was not clinically identified until March 4, 1999.

Blood clots, or thrombus formation, in coronary arteries are initiated by disruption of atherosclerotic plaques. Certain characteristics of the plaques (size, composition of the cap and core, presence of a local inflammatory process) predispose the plaque to disruption.[5] Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate, increased catecholamines, and shear forces, which occur during heavy exercise.[6,7]

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.[8] Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.[9-11] Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[12-16] The victim had walked from the hydrant up to the third floor of the structure while wearing full bunker gear; this is considered "heavy work" typically requiring over 6 METS.[17,18]

The Department requires a preplacement medical examination for all new hires and annual medical evaluations. While the Fire Department should be commended for conducting annual medical evaluations/examinations, it should be noted that they differ in two areas with National Fire Protection Association (NFPA) Standard 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians. First, while NFPA recommends annual medical evaluations, they recommend extensive medical examinations on a periodic basis according to the age of the fire fighter (less than 30: every 3 years; 30-39: every 2 years; over 40 years: every year).[19] The second difference with NFPA 1582 is that NFPA 1582 recommends fire fighters over the age of 35 with risk factors for CAD undergo an EST.[19]

The EST can be used to screen individuals for obstructive CAD . Unfortunately, it has problems with both false negatives (inadequate sensitivity) and false positives (inadequate specificity), particularly for asymptomatic individuals (individuals without symptoms suggestive of angina), young men, and women.[20,21] Despite these problems, NFPA 1582 continues to recommend EST for fire fighters without risk factors for CAD beginning at age 40.[19] Other expert groups do **not** recommend EST for asymptomatic individuals without risk factors for CAD.[22-24]

When these asymptomatic individuals **have** risk factors for CAD, as was the case with this victim prior to his heart attack in 1997, recommendations

vary by organization. As mentioned previously, NFPA recommends biannual EST for fire fighters with CAD risk factors beginning at age 35.[19] The medical certification for the commercial drivers license (CDL) issued by the Department of Transportation (DOT) recommends EST for drivers over the age of 45 with more than two CAD risk factors.[22] Since the victim was a Driver/Operator for the Fire Department, this regulation would seem to have relevance, but miliary installations and municipal fire departments are exempt from the DOT regulations.[25] In addition, the DOT medical advisory criteria are just that, advisory. The American College of Cardiology/American Heart Association (ACC/AHA) identifies four groups for EST, although they note that the "usefulness/efficacy is less well established by evidence/opinion."[23]

- Group 1: Persons with multiple risk factors. Five risk factors for CAD are defined: hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (systolic greater than 140 mm Hg or diastolic greater than 90 mm Hg), smoking, diabetes, and family history of premature CAD (cardiac event in 1st degree relative less than 60 years old).
- Group 2: men over the age of 40 and women over the age of 50 (especially if sedentary) who plan to start vigorous exercise.
- Group 3: men over the age of 40 and women over the age of 50 who are at high risk for CAD due to other diseases (e.g. chronic renal failure).
- Group 4: men over the age of 40 and women over the age of 50 who are involved in occupations in which impairment might impact public safety.

The victim had the criteria to meet the conditions of Group 1 and Group 4.

Finally, it is important to note that the U.S. Preventive Services Task Force (USPSTF) does not recommend EST for asymptomatic individuals, even those with risk factors for CAD; rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes).[24] The USPSTF indicates that there is insufficient evidence to recommend screening middle age and older men or women in the general population; however, "screening individuals in certain occupations (pilots, truck drivers, etc.) can be recommended on other grounds, including the possible benefits to public safety."[24]

The above discussion focuses on using the EST to screen or diagnose CAD. Once this victim had his heart attack in 1997, there were other reasons to conduct periodic EST. The ACC/AHA considers the periodic monitoring of selected, high-risk asymptomatic revascularized patients for restenosis, graft occlusion, or disease progression to be a category IIb condition ["usefulness/efficacy is less well established by evidence/opinion"].[23] This victim would be considered high risk due to his multivessel CAD, proximal LAD disease, and diabetes mellitus.[23] Post-heart attack, the DOT recommends ESTs be conducted 1) before returning to work, 2) one-year post-heart attack, and 3) every two years until age 55, and then yearly.[22]

The above discussion suggests that, although not required by law, an EST would have been valuable prior to, and after, this victim's heart attack in 1997. When the victim finally had an EST on the March 11, 1999, the results were disconcerting. While the victim did reach stage III of the Bruce protocol, 10.6 METS, and 85% of his targeted heart rate, he also experienced chest pressure and had an inadequate systolic blood pressure response. Furthermore, the imaging study results available to NIOSH did not rule out some persistent myocardial ischemia. These findings suggest that his EST could be interpreted as "positive or indeterminate," and coupled with his reduced left ventricular ejection fraction (35%) diagnosed by echocardiogram, raises the question whether his heart disease should have precluded his

full return to duty. NFPA 1582 considers individuals with CAD (history of myocardial infarction, coronary artery bypass surgery, or coronary angioplasty) to be a "Category B Medical Condition." A Category B Medical Condition is defined as "a medical condition that, based on its severity or degree, **could** (our emphasis) preclude a person from performing as a fire fighter in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others." Appendix A of the Standard contains guidance for when to preclude a fire fighter with CAD from engaging in fire fighting activities. Appendix A states that "Persons at mildly increased risk for sudden incapacitation are acceptable for fire fighting. Mildly increased risk is defined by the presence of each of the following:

- Normal left ventricular ejection fraction
- Normal exercise tolerance, > 10 metabolic equivalents (METS)
- Absence of exercise-induced ischemia by exercise testing
- Absence of exercise-induced complex ventricular arrhythmias
- Absence of hemodynamically significant stenosis of all major coronary arteries ($ 70 percent lumen diameter narrowing), or successful myocardial revascularization."

Based on this Lieutenant's catheterization in 1997 and his EST and echocardiogram in March 1999, he did not meet the first and fifth criterion, and possibly the third criterion. Therefore, he probably should not have been cleared for full fire fighting duties without further treatment of his heart disease. In addition, according to DOT regulations, the victim's use of insulin to control his diabetes mellitus would preclude his operating a commercial motor vehicle.[25]

RECOMMENDATIONS

The following recommendations address health and safety issues identified during this investigation. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job cardiac arrest among fire fighters. These recommendations have not been evaluated by NIOSH, but represent published research or of consensus votes of Technical Committees of the National Fire Protection Association or labor/management groups within the fire service.

Recommendation #1: Incorporate exercise stress tests into the Fire Department's medical evaluation program.

NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians, and the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative both recommend at least biannual EST for fire fighters.[19,26] They recommend that these tests begin at age 35 for those with CAD risk factors, and at age 40 for those without CAD risk factors. The EST could be conducted by the fire fighter's personal physician (at Fire Department expense) or the Installation physician. If the fire fighter's personal physician conducts the test, the results must be communicated to the Installation physician, who should be responsible for decisions regarding medical clearance for fire fighting duties.

Recommendation #2: Preclude those individuals with medical conditions that would present a significant risk to the safety and health of themselves or others.

NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians, lists medical conditions that **should** (Category A) or **could** (Category B) preclude individuals from performing fire fighting activities.[19] We recommend fire departments adopt these recommendations and share this

Standard (NFPA 1582) with physicians responsible for these decisions.

Recommendation #3: Clear fire fighters for duty by a physician knowledgeable about the physical demands of fire fighting and the various components of NFPA 1582.

Physicians providing input regarding medical clearance for fire fighting duties should be knowledgeable about the physical demands of firefighting and familiar with the consensus guidelines published by NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians. To ensure private physicians are aware of these guidelines, we recommend that the Installation Preventive Medicine clinic provide them with a copy of NFPA 1582. In addition, we recommend the Installation Preventive Medicine clinic not automatically accept the opinion of the employee's private physician regarding return to work; depending on the victim's condition and injury/illness, and the job duties of the victim. The final decision regarding medical clearance for return to work lies with the Installation physician with input from many sources including the employee's private physician.

Recommendation #4: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[27] The International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) joined in a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual and a video detailing elements of such a program.[26] Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.[28-30] A similar cost savings has been reported by the Wellness program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.[31]

Recommendation #5: Integrate all emergency services dispatching into one communication center.

In January 1968, a proposal was made to implement throughout the country a single national emergency number (911) or Public Safety Answering Point (PSAP) that the public could use to reach the police, fire department, and other emergency agencies.[32] To maximize public safety, emergency responder safety, and efficiency, a communication center should provide: (1) communications between the public and the communication center, (2) communications between the communication centers, the emergency response agency (ERA), and the emergency response facility (ERF), and (3) communications within the ERA and between different ERA.[32] Radios, telephones, and other electronic equipment, operating procedures, and personnel training should enable messages to be conveyed as quickly and reliably as a situation requires. Messages should be sent and received correctly without delay. Alarms shall be retransmitted to emergency response facilities from the location at which alarms are received. Alarms from the communication center shall be automatically received at emergency response facilities.[32] Emergency units should be dispatched

within 60 seconds after the completed receipt of an emergency alarm.[32] Time delay and the number of messages to be handled are directly related to proper service.

After a call for help has been received at a PSAP, there are four methods by which it can be handled: direct dispatch, alternate routing, selective routing, and transfer. Transfer is currently in use at this Installation. A telephone request for emergency medical service is received at the 911 Center, who then transfers the request by direct link telephone to the hospital operators, who then dispatch the ambulance. While this method only takes an additional few seconds to dispatch an ambulance, and probably did not contribute to the victim's death, it incorporates an additional dispatch function. The most efficient method of dispatch is direct dispatch, where the dispatch personnel at the central answering point perform all call answering and dispatching of the appropriate emergency service unit.[32] Because of the complexity of the job, dispatchers need extensive training, and non-emergency calls should be transferred to non-emergency telephone operators.[32-34]

Recommendation #6: Provide adequate fire fighter staffing to ensure safe operating conditions.

The staffing issue is not related, in any way, to the death of this fire fighter. Rather, it addresses a safety issue identified during this investigation.

The Fire Department is currently comprised of one Fire Chief, one Acting Deputy Chief, two Assistant Chiefs, three Inspectors, ten Captains, 18 Driver/Operators (Lieutenants), and 22 Fire Fighters, and operates from a total of four fire stations. Daily shifts are comprised of one Fire Chief, one Acting Deputy Chief, one Assistant Chief, one or two Inspectors, five Captains, nine Driver/Operators, and 11 Fire Fighters. Typically, an Engine is staffed with four personnel, an ARFF apparatus is staffed with three personnel, and the Ladder Truck is staffed with one person. However, due to sick leave and vacations, apparatus staffing often falls to three personnel or less. NFPA 1500 recommends a minimum of four fire fighters be present where only one team (company) is operating in the hazardous area at a working structural fire; two individuals working as a team in the hazard area and two individuals present outside this hazard area for assistance or rescue.[27] This could be accomplished by any of the following: 1) increasing the number of fire fighters assigned to a company, 2) hiring fire fighters to act as "floaters" to fill in positions vacated by employees who are sick or who are on vacation, 3) staggering vacation days in conjunction with hiring floating fire fighters. The basis for this standard is improvement of worker safety while fighting interior structural fires. Department of Defense Instruction (DODI) 6055.6 requires that "emergency responses to immediately dangerous to life or health (IDLH) atmospheres shall meet the requirements of OSHA's Respiratory Protection Program including the two in/two out provisions for interior structure and aircraft fires."[33,35] However, DODI 6055.6 also sets minimum apparatus staffing at four personnel per aerial ladder and structural apparatus, but only three per Aircraft Rescue and Fire Fighting (ARFF) apparatus. Therefore, ARFF apparatus staffing does not meet the requirements of either DODI 6055.6 nor OSHA. Also DODI 6055.6 authorizes staffing of a full-time Deputy Chief (based on the number of fire companies) and six inspectors (based on the area of space requiring fire risk surveys). Currently, an Assistant Chief is performing the duties and responsibilities of the Deputy Chief and three Inspectors are performing the duties of the six authorized. It is recommended that at least the following personnel be hired to meet the staffing standards for management, fire prevention, and apparatus (Station 1, 3, and 4): a Deputy Chief,

three Inspectors, one Captain, and four Fire Fighters.

Currently, Station 2 houses an Engine and an ARFF apparatus, with only one apparatus being staffed. When the Engine is out on call, the Heliport must be closed or an ARFF apparatus is moved-up from Station 3 or Station 4 (which will leave Station 4 empty). Additional staffing for Station 2 should also be considered (DODI 6055.6, para. E2.5.14 and E2.5.15).[33]

REFERENCES

1. Meyerburg RJ, Castellanos A [1998]. Cardiovascular collapse, cardiac arrest, and sudden cardiac death. In: Braunwald E, Fauci AS, Kapser DL, Hauser SL, Longo DL, Jameson JL, eds. Harrison's principles of internal medicine. 14th Edition. New York: McGraw-Hill. pp. 222 225.

2. AHA [1998]. AHA Scientific Position, Risk Factors for Coronary Artery Disease. Dallas, TX: American Heart Association.

3. Libby P [1998]. The pathogenesis of atherosclerosis. In: Braunwald E, Fauci AS, Kasper DL, Hauser SL, Longo DL, Jameson JL, eds. Harrison's principles of internal medicine. 14th Edition. New York: McGraw-Hill. p.1348.

4. Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. Clin Cardiol 20 (11 Suppl2): II-38-44.

5. Fuster V, Badimon JJ, Badimon JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. N Eng J Med 326: 242 250.

6. Kondo NI, Muller JE [1995]. Triggering of acute myocardial infarction. J Cardiovasc Risk 2(6):499 504.

7. Opie LH [1995]. New concepts regarding events that lead to myocardial infarction. Cardiovasc Drug Ther 9 Suppl 3:479 487.

8. Gledhill N, Jamnik, VK [1992]. Characterization of the physical demands of firefighting. Can J Spt Sci 17:3 207 213.

9. Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of fire fighters. J Occup Med 17: 247 250.

10. Manning JE, Griggs TR [1983]. Heart rate in fire fighters using light and heavy breathing equipment: Simulated near maximal exertion in response to multiple work load conditions. J Occup Med 25:215 218.

11. Lemon PW, Hermiston RT [1977]. The human energy cost of fire fighting. J Occup Med 19:558 562.

12. Willich SN, Lewis M, Lowel H, et al. [1993]. Physical exertion as a trigger of acute myocardial infarction. N Eng J Med 329:1684 1690.

13. Mittleman MA, Maclure M, Tofler GH, et al. [1993]. Triggering of acute myocardial infarction by heavy physical exertion. N Eng J Med 329:1677 1683.

14. Siscovick DS, Weiss NS, Fletcher RH, Lasky T [1984]. The incidence of primary cardiac arrest during vigorous exercise. N Eng J Med 311:874 877.

15. Tofler GH, Muller JE, Stone PH, et al. [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 20:1049 1055.

16. Albert CM, Mitleman MA, Chae CU, et al. [2000] Triggering of sudden death for cardiac causes by vigorous exercise. N Eng J Med 343:1555 1561.

17. O'Connell ER, Thomas PC, Cady LD, Karwasky RJ [1986]. Energy costs of simulated stair climbing as a job-related task in fire fighting. J Occup Med 28:282 284.

18. American Industrial Hygiene Association Journal [1971]. Ergonomics guide to assessment of metabolic and cardiac costs of physical work. Am Ind Hyg Assoc J 560 564.

19. NFPA [2000]. Standard on medical requirements for fire fighters and information for fire department physicians. Quincy MA: National Fire Protection Association. NFPA 1582 2000.

20. Michaelides AP, Psomadaki ZD, Dilaveris PE, et al. [1999]. Improved detection of coronary artery disease by exercise electrocardiography with the use of right precordial leads. New Eng J Med 340:340 345.

21. Darrow MD [1999]. Ordering and understanding the exercise stress test. American Family Physician. January 15, 1999.

22. CFR. Medical Advisory Criteria for Evaluation under 49 CFR Part 391.41. Code of Federal Regulations. Washington, DC: National Archives and Records Administration, Office of the Federal Register. Available from the DOT web site at: http://www.occenvmed.net/dot/cardioconf.htm

23. Gibbons RJ, Balady GJ, Beasley JW, Bricker JT, Duvernoy WFC, Froelicher VF, Mark DB, Marwick TH, McCallister BD, Thompson PD, Winters WL Jr, Yanowitz FG [1997]. ACC/AHA guidelines for exercise testing: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). *J Am Coll Cardiol*. 30:260 315.

24. U.S. Preventive Services Task Force [1996]. Guide to clinical prevention services, 2nd Ed. Baltimore, MD: Williams & Wilkins, pp. 3 15.

25. CFR. 49 CFR 391.41: Subpart E — Physical Qualifications and Examinations. Code of Federal Regulations. Washington, DC: National Archives and Records Administration, Office of the Federal Register.

26. IAFF, IAFC. [2000]. The fire service joint labor management wellness/fitness initiative. Washington, D.C.: International Association of Fire Fighters, International Association of Fire Chiefs.

27. NFPA [1997]. Standard on fire department occupational safety and health program. Quincy MA: National Fire Protection Association. NFPA 1500 1997.

28. National Institute of Consulting Services [1996].

29. Maniscalco P, Lane R, Welke M, Mitchell J, Husting L [1999]. Decreased rate of back injuries through a wellness program for offshore petroleum employees. J Occup Environ Med 41:813 820.

30. 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 42:1148 1155.

31. City Auditor, City of Phoenix, AZ [1997]. Disability retirement program evaluation. Jan 28, 1997.

32. NFPA [1999]. Standard for the installation, maintenance, and use of public fire service communication systems. Quincy MA: National Fire Protection Association. NFPA 1221 1999.

33. DOD [2000]. DODI 6055.6, DOD Fire and Emergency Services Program. Washington DC: Department of Defense.

34. NFPA [1996]. Standard for professional qualifications for public safety telecommunicator. Quincy MA: National Fire Protection Association. NFPA 1061 1996.

35. CFR. 29 CFR 1910.134, Respiratory protection. Code of Federal Regulations. Washington, DC: National Archives and Records Administration, Office of the Federal Register.

INVESTIGATOR INFORMATION

This investigation was conducted by and the report written by Tommy N. Baldwin, MS, Safety and Occupational Health Specialist. Mr. Baldwin is with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio.