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NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation *March 5, 2003*

Fire Fighter Dies During the Night at Fire Station - Kansas

SUMMARY

On April 5, 2002, a 30-year-old male career fire fighter on duty at his fire station went to bed at approximately 1030 hours. On April 6, 2002, at 0550 hours, his engine company was dispatched to a forced-entry call. The victim did not respond to the alarm, and when crew members checked on him, they found the victim unresponsive, with no pulse and no respirations. Cardiopulmonary resuscitation (CPR) was begun immediately and an extra ambulance was requested. The ambulance arrived on the scene 5 minutes later. Approximately 29 minutes later, despite CPR and advanced life support (ALS) administered on the scene and at the hospital, the victim died. The autopsy and death certificate, completed by the County Coroner, listed "cardiac arrhythmia due to mitral valve prolapse" as the cause of death.

The following recommendations address some general health and safety issues. 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 they represent published research or consensus votes of technical committees of the National Fire Protection Association (NFPA) or fire service labor/management groups. However, it is unlikely that any of these recommendations could have prevented the unfortunate death of this fire fighter.

- ***Conduct <u>mandatory</u> preplacement and periodic medical evaluations consistent with NFPA 1582 to determine a candidate's medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***
- ***Follow provisions in the revised OSHA respiratory protection standard.***

INTRODUCTION & METHODS

On April 6, 2002, a 30-year-old male fire fighter was found in his bunk unresponsive, not breathing, and pulseless. Despite CPR and ALS administered by crew members, the ambulance crew, and personnel in the hospital's emergency department, the victim died. On April 12, 2002, NIOSH contacted the affected Fire Department to initiate the investigation. On April 29, 2002, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Kansas to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed the

- Fire Chief
- Deputy Chief
- Director of Human Resources
- Crew members on duty with the victim
- Police Chief
- Victim's parent

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at **www.cdc.gov/niosh/firehome.html** or call toll free **1-800-35-NIOSH**

Fire Fighter Dies During the Night at Fire Station - Kansas

During the site visit NIOSH personnel reviewed the following:

- Fire Department policies and operating guidelines
- Fire Department training records
- Fire Department annual report for 2001
- Fire Department incident report
- Emergency medical service (ambulance) incident report
- Hospital emergency department report
- Death certificate
- Autopsy report
- Past medical records of the deceased

INVESTIGATIVE RESULTS

Incident. On April 5, 2002, the victim arrived at his fire station, Station 1, for work at 0730 hours. Station 1 housed Engine 41, Quint 41, Ambulance 441, and Haz Mat 41. The victim was assigned to drive Engine 41. After checking the equipment, the crew began to remodel a portion of the fire station, which involved moving some lockers. At 1406 hours, Engine 41, Quint 41, Engine 61, Engine 621, Ambulance 441, Med-Act 1143, and Battalion Chief 405 were dispatched to a broken gas line at a dwelling. On the scene, Quint 41 personnel used a combustible gas indicator and a thermal imaging camera to investigate the conditions of the structure. Finding no fire, but a carbon monoxide level of 30 ppm, they began ventilation procedures. All other units were released and Engine 41 returned to its station and crew members continued remodeling. The Engine 41 crew ate dinner at approximately 1800 hours and the victim went to bed at approximately 2230 hours. Ambulance 441 was dispatched to a call at 0130 hours which awoke the entire station. One crew member passed by the victim in the hallway and spoke to him. The victim appeared to be in no distress or having any symptoms of distress. The remaining crew members in the station went back to sleep. At 0550 hours, Engine 41 and Ambulance 441 were dispatched to a forced-entry call. The victim, who had a reputation as being difficult to awaken, did not respond to the call. Crew members yelled at him to get up and eventually they turned the lights on in his bunk room, where he was found to be not breathing, pulseless, cyanotic, and mottled. CPR (chest compressions and assisted ventilations with 100% oxygen via bag-valve-mask) was begun immediately. The station Captain notified Dispatch of the situation. Dispatch immediately notified the ambulance (Med-Act 1141) and the EMS supervisor (1103) at 0551 hours.

Initial ECG monitoring revealed asystole (no heartbeat). The victim was intubated and an IV was established. CPR was continued as ALS medications were administered and cardiac pacing attempted, with no change in patient status. Med-Act 1141 arrived at the fire station at 0556 hours. The victim was placed onto a long spine board, loaded into Med-Act 1141, and transported to a nearby hospital at 0606 hours, arriving at the hospital emergency department at 0609 hours. Inside the emergency department, a cardiac monitor revealed asystole and attempted cardiac pacing continued with no change in patient status. CPR and ALS measures continued until 0625 hours, when the victim was pronounced dead by the attending physician.

Medical Findings. The death certificate was completed by the County Coroner, who listed "cardiac arrhythmia due to mitral valve prolapse" as the immediate cause of death. The carboxyhemoglobin level was less than 10%, suggesting that carbon monoxide poisoning was not responsible for his demise. His urine and blood drug screen was negative for illicit drugs and alcohol. Pertinent findings from the autopsy, also performed by the County Coroner on April 6, 2002, included

1. Normal sized heart of 360 grams (normal < 400 grams).

2. Moderate myxomatous degeneration, mitral valve with endocardial friction lesions.
3. Foci of myofiber bundle disorder and myocyte disarray of the left ventricle on microscopic examination.
4. Normal coronary arteries.
5. Possible acutely dilated right ventricle.

The fire fighter had only one risk factor for coronary artery disease (CAD): male gender. The victim was not currently prescribed any medications. In September 2001 the victim underwent a routine Fire Department physical examination. The exam revealed a height of 6' 3", a weight of 173 pounds, and a blood pressure of 126/74. All components of the lipid survey were within normal limits except for HDL, which was 30 mg/dl (normal range of 35-60 mg/dl). He was not under any restrictions for fire-fighting duties.

According to his mother and coworkers, the fire fighter did not express symptoms of chest pain, shortness of breath, or any other symptom indicative of a heart condition at any time preceding the incident.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the combination Fire Department consisted of 130 uniformed fire fighters (117 paid and 13 volunteer members) and served a population of 160,000 in a geographic area of 62 square miles. There are five fire stations. Fire fighters work the following schedule: 24 hours on duty, 24 hours off duty, from 0800 hours to 0800 hours for five shifts, then off duty for 4 days.

In 2001 the Fire Department responded to 11,545 calls: 7,863 medical calls, 1,164 false alarms, 869 good-intent calls, 531 hazardous-condition calls, 335 service calls, 190 structure fires, 171 rescue/medical calls, 105 vehicle fires, 74 wildland/vegetation fires, 66 trash/rubbish fires, 51 other fires, 46 severe weather/natural disaster calls, 42 overpressure/ rupture/overheat calls, 27 other outside fires, and 11 special-incident calls.

Training. New career fire fighter applicants are required to be previously certified as Fire Fighter I and an EMT at the time of application, pass a written test, a physical agility test (PAT), an oral interview, and a reference check before being hired. Once hired, the fire fighter must pass a preplacement physical examination, including an exercise treadmill test (EST), and a psychological examination before being assigned to a shift. Once assigned to a shift, the fire fighter is on probation for 1 year. A 6-year-step process is required to advance the fire fighter to the top of the fire fighter pay scale. Once at the top of this scale, the individual is eligible to test for Lieutenant. Fire fighters receive recurrent training in their station on each shift and attend mandatory fire fighter/EMS training monthly.

Volunteer fire fighter applicants must be previously certified as Fire Fighter I and pass a preplacement physical examination before being assigned to a shift. Volunteers must spend a minimum of 24 hours on duty monthly and participate in the mandatory monthly fire fighter/ EMS training.

The State minimum requirement for initial fire fighter certification is the 120-hour program administered through Kansas University Fire Training. The State does not require annual fire fighter recertification. Annual recertification is required for hazardous-materials certification. EMTs and Paramedics recertify every 2 years. The victim was trained as a Fire Fighter II, Driver/ Operator, EMT, and a Police Officer, and he had 11 years of fire-fighting experience (including 19 months as a volunteer).

Preplacement Evaluations. The Fire Department requires a preplacement medical evaluation for both career and volunteer new hires. Components of the preplacement medical evaluation include

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Vision test
- Audiogram
- Blood tests: complete blood count with differential (CBC), chemistry, lipid, and liver profile
- Urine tests: urinalysis, drug screen
- Resting electrocardiogram (ECG)
- EST
- Hepatitis B Titer
- Anthropometrics
- Strength/Flexibility tests
- Tuberculosis Mantoux test
- Immunization questionnaire

A baseline chest X-ray is only performed for Hazardous Materials-certified fire fighters.

A timed performance evaluation of typical fire-fighting duties (PAT) is also required. Prior medical clearance is not required for taking the PAT.

Periodic Evaluations. Periodic medical evaluations are required by the Fire Department for all career fire fighters annually if over age 40, biannually if over age 30, and every 3 years if under age 30. Components of the periodic medical evaluation for fire fighters under age 50 include

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Vision test
- Audiogram
- Blood tests: CBC, chemistry, lipid, and liver profile
- Urine tests: urinalysis, drug screen
- ECG
- EST
- Tuberculosis Mantoux test
- Immunization questionnaire

Career fire fighters over the age 50 also receive

- Protein specific antigen/digital rectal exam (PSA/DRE)
- Anthropometrics
- Strength/Flexibility test

Volunteer fire fighters do not receive periodic medical evaluations.

Medical clearance for self-contained breathing apparatus (SCBA) is not conducted by this Fire Department. If a fire fighter is injured on duty or misses three or more shifts due to illness/injury, he/she must be cleared for return to work either by a physician approved by the State Worker's Compensation Board, the contract physician, or the fire fighter's private physician, depending on the nature and severity of the injury.

The Fire Department requires fire fighters to participate in a mandatory physical fitness program. A specific time is allotted each shift for exercise. Strength and aerobic equipment is available in each fire station. Voluntary wellness programs are available through the contract physician.

DISCUSSION

The autopsy revealed no coronary artery disease (CAD) and no thrombus; therefore, the victim did not suffer a heart attack (myocardial infarction). The autopsy did find the following: "moderate myxomatous degeneration, mitral valve with endocardial friction lesions," "foci of myofiber bundle disorder and myocyte disarray of the left ventricle on microscopic examination," "normal coronary arteries," and "possible acutely dilated right ventricle."

Histologic lesions are consistent with hypertrophic cardiomyopathy, yet his heart size was normal. Since hypertrophic cardiomyopathy typically requires a macroscopic finding of cardiomegaly (heart weighing over 400 grams)[1], his most likely diagnosis was "cardiac arrhythmia due to mitral valve prolapse" as the immediate cause of death.

Mitral valve prolapse (MVP) syndrome is "a variable clinical syndrome that results from diverse pathogenic mechanisms of one or more portions of the mitral valve (e.g., mitral valve apparatus, valve leaflets, chordae tendineae, papillary muscle, and valve annulus)."[2] It occurs in only 2.4 percent of the population and is twice as frequent in females as in males.[2] MVP is commonly seen in patients with rare inheritable disorders of connective tissue (e.g., Marfan syndrome, Ehlers-Danlos syndrome, osteogenesis imperfecta, pseudoxanthoma elasticum, periarteritis nodosa, myotonic dystrophy, von Willebrand disease, etc.), congenital malformations (e.g., Ebstein anomaly of the tricuspid valve, atrial septal defect of the ostium secundum variety, the Holt-Oram syndrome), and hypertrophic cardiomyopathy.

Findings of MVP include myxomatous proliferation of the mitral valve, in which the spongiosa component of the valve (i.e., the middle layer of the leaflet composed of loose, myxomatous material) is unusually prominent.[2] Although the majority of patients with MVP exhibit myxomatous degeneration of the valve, post-inflammatory changes may also be responsible for prolapse.[2]

The MVP syndrome appears to exhibit a strong hereditary component, and in some patients is transmitted as an autosomal dominant trait with varying penetrance.[2] A large majority of patients with MVP are asymptomatic and remain so throughout their lives.[2] The ECG is usually normal in asymptomatic patients with MVP. A spectrum of arrhythmias have been observed, including atrial and ventricular premature contractions, supraventricular and ventricular tachyarrhythmias, and bradyarrhythmias due to sinus node dysfunction or varying degrees of atrioventricular block.[2]

The best evidence suggests that MVP slightly increases the risk of sudden death, especially in patients with severe mitral regurgitation or severe valvular deformity. The immediate cause of the sudden, unexpected death is probably ventricular fibrillation.[2] The victim did not have mitral regurgitation nor valvular deformity. When findings are normal, i.e., when there is no evidence of stress-induced regional myocardial ischemia, the diagnosis of MVP unrelated to ischemic heart disease is favored.[2]

Myofiber bundle disorder and myocyte disarray were histologically identified involving the lateral and posterior-lateral walls of the left ventricle. This histologic abnormality is seen in patients with hypertrophic cardiomyopathy (usually asymmetric type). Although the findings were present in the victim, the significance is unknown in the setting of a normal-sized heart without hypertrophy or asymmetry.

The Fire Fighter had only one risk factor for coronary artery disease (CAD): male gender.

In 2000, the National Fire Protection Association (NFPA) updated Standard 1582, *Medical Requirements for Fire Fighters and Information for Fire Department Physicians.*[3] This voluntary industry standard specifies minimum medical requirements for candidates and current fire fighters. NFPA 1582 considers valvular heart disease to be a Category B condition, that is, "a medical condition that, based on its severity or degree, **could** [our emphasis] preclude a person from performing as a member in a training or emergency operational environment by presenting a significant risk to the safety and health of the member or others."[3] Mitral

insufficiency is "acceptable if in sinus rhythm with normal left ventricular size and function."[3] Once again, without tests of the left ventricular size or function, we cannot determine if this criterion was met.

Dilated cardiomyopathy is not specifically addressed in the standard. However, at a minimum, it would be considered a Category B Medical Condition. It is unlikely that the periodic medical evaluation recommended by NFPA 1582, including exercise stress testing (NFPA 1582 Appendix B),[3] would have detected, let alone prevented, this unfortunate event from occurring.

RECOMMENDATIONS

The following recommendations address health and safety generally. Recommended screening would not have picked up this victim's condition; therefore, unfortunately, none of these recommendations could have prevented the sudden cardiac arrest and subsequent death of this fire fighter. 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 recommendations have not been evaluated by NIOSH, but they represent published research or consensus votes of technical committees of the NFPA or fire service labor/management groups.

Recommendation #1: Conduct <u>mandatory</u> preplacement and periodic medical evaluations consistent with NFPA 1582 to determine a candidate's medical ability to perform duties without presenting a significant risk to the safety an health of themselves or others.

Guidance regarding the content and frequency of preplacement and periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582, *S tandard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians*,[3] and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.[4] The Department is not legally required to follow any of these standards. Nonetheless, we recommend the City and the Fire Department be consistent with the above guidelines. Currently, the preplacement exam contains all the NFPA-recommended components except for a baseline chest X-ray. Periodic medical evaluations are offered to career fire fighters only.

In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire-fighting tasks. NFPA 1582 should be applied in a **confidential**, **nondiscriminatory** manner. Appendix D of NFPA 1582 provides guidance for fire department administrators regarding legal considerations in applying the standard.

Applying NFPA 1582 also involves economic issues. These economic concerns go beyond the costs of administering the medical program; they involve the personal and economic costs of dealing with the medical evaluation results. NFPA 1500, *S tandard on Fire Department Occupational S afety and Health Program,* addresses these issues in Chapter 8-7.1 and 8-7.2.[5]

The success of medical programs hinges on protecting the affected fire fighter. The Department must (1) keep the medical records confidential, (2) provide alternate-duty positions for fire fighters in rehabilitation programs, and (3) if the fire fighter is not medically qualified to return to active fire-fighting duties, provide permanent alternate duty positions or other supportive and/or compensated alternatives.

Recommendation #2: Follow provisions in the revised OSHA respiratory protection standard.

OSHA's Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection.[6] These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. Kansas is not a State-plan State; therefore, public-sector employers, including fire departments, are required to comply with OSHA standards. However, this Fire Department is a not-for-profit private employer, and, therefore, is required to comply with federal OSHA standards. A copy of the OSHA medical checklist has been provided to the Fire Department.

REFERENCES

1. Braunwald E, Zipes D, Libby P [2001]. Heart disease. In: A textbook of cardiovascular medicine. 6th ed. Philadelphia: Saunders, p.1761.

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

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

5. NFPA [1997]. NFPA 1500, Standard on fire department occupational safety and health program. Quincy, MA: NFPA.

6. 29 CFR 1910.134. Code of Federal Regulations. Occupational Safety and Health Administration: Respiratory Protection. Washington, DC: National Archives and Records Administration, Office of the Federal Register.

INVESTIGATOR INFORMATION

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