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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 *July 7, 2003*

Fire Fighter Suffers Sudden Cardiac Death at a Structural Fire - New York

SUMMARY

On August 28, 2001, a 27-year-old male first-year fire fighter responded to a structural fire at an auto body shop. The victim donned his personal protective equipment weighing approximately 60 pounds and walked about 150 feet toward the fire building while re-positioning uncharged hose lines. At that time he apparently began to experience difficulty breathing. He did not notify crew members of his symptoms nor did he notify them that he was returning to their apparatus. When he arrived at the apparatus, a civilian witness noticed he was in severe respiratory distress as he climbed into the rig's cab.

The incident was a three alarm fire eventually involving 138 fire fighters from 33 units. After several minutes in front of the fire building, the victim's Officer noticed he was missing. The Officer ordered a local search conducted by the victim's partner. After another few minutes of being unable to locate the victim, the Officer notified the Incident Commander who issued a "Mayday" alert. Approximately five minutes later, the victim was found unresponsive without a pulse or spontaneous respiration in the riding position of the rig's cab. Despite cardiopulmonary resuscitation (CPR) and advanced life support (ALS) administered by on-scene emergency medical service (EMS) personnel and hospital emergency department personnel, the victim died. The death certificate and the autopsy was completed by the Medical Examiner's Office listed "hypertrophic cardiomyopathy with myocardial arteriolarsclerosis" as the immediate cause of death with a "myxomatous mitral value" as a contributing cause of death.

A number of agencies have developed preventive measures to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. This strategy consists of: 1) minimizing physical stress on fire fighters; 2) screening to identify and subsequently rehabilitate high risk individuals; and 3) encouraging increased individual physical capacity. This strategy has not been evaluated by NIOSH, but represents research presented in the literature, consensus votes of Technical Committees of the NFPA, or labor/management groups within the fire service. Most, if not all, of these measures are already being followed by this Fire Department (FD). Therefore, it is unlikely the FD could have prevented this fire fighter's untimely death. Nonetheless, potentially relevant issues applicable to this FD include:

- ***Emphasize the importance of communication and accountability on the fire ground, particular to fire fighters with minimal fire ground experience.***
- ***Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by emphasizing the Fire Department's mandatory wellness/fitness program.***

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 Suffers Sudden Cardiac Death at a Structural Fire - New York

INTRODUCTION & METHODS

On August 28, 2001, a 27-year-old male fire fighter experienced shortness of breath while beginning to support fire suppression activities at a structural fire. He returned to his apparatus and had an unwitnessed collapse inside the cab. He was found approximately five to ten minutes later. Despite treatment by on-scene fire fighters, EMS paramedics, and subsequent resuscitation efforts in the hospital emergency department, the victim died. NIOSH was notified of this fatality in September 2001, by the United States Fire Administration. In October, 2002, NIOSH contacted the affected FD to initiate the investigation. On December 2, 2002, an occupational physician, a safety specialist, and an occupational health nurse practitioner from the NIOSH Fire Fighter Fatality Investigation Team traveled to New York to conduct an onsite investigation of the incident.

During the investigation NIOSH personnel met and/or interviewed the:

- FD Chief of Safety
- FD Executive Officer, Safety Command;
- FD Deputy Chief Medical Officer;
- FD Director of Occupational Safety and Health;
- Local Union Safety Representative;
- Company members on-duty with the victim;
- Victim's wife.

During the site-visit NIOSH personnel reviewed:

- FD investigative report of the fatality;
- FD policies and operating guidelines;
- FD training records of the victim;
- FD medical records of the victim;
- FD annual report for 2001;
- EMS (ambulance) report;
- Death certificate;
- Autopsy report.

INVESTIGATIVE RESULTS

Incident. On August 28, 2001, at 1432 hours, the local Communications Office received a no contact box alarm followed 20 seconds later by an alarm reporting a private dwelling fire. One Engine company (157), two Ladder companies (79 & 80), and a Battalion Chief (22) were initially assigned. At 1434 hours a third call reported the fire had spread to a second structure and additional units were assigned to the response [Engine 163 (the victim's company), Ladder 83, and Rescue 5].

The fire building was a two story auto body repair shop measuring 30 feet by 50 feet. At 1435 hours Engine 157 was the first on-scene and noted the full involvement of the fire building with extension to the adjacent building (exposure 2). At 1436 hours Engine 157 requested a "total response" (known as a 10-75) at the same time the Battalion Chief requested a "total response" due to a rising column of smoke as he approached the fire. A total response requires the response of the following vehicles: four-Engine companies, two-Ladder companies, two-Battalion Chiefs, one-"FAST" unit, one-Squad company (if available), and one-Rescue company (if available). Exposure 2 was also a two story automobile repair shop of mixed construction measuring 40 feet by 75 feet. Ultimately, the fire went to a third alarm and a total of 138 fire fighters from 33 units responding.

The Battalion Chief arrived on-scene as the fire building began to collapse (1437 hours). Engine 157 connected to a fire hydrant in front of the fire building and stretched a handline hose to exposure 2 which was later repositioned to operate on the original fire building. They also dropped a 31/2 inch line at a previous hydrant anticipating in-line pumping. Engine 156 stretched a second handline from Engine 157's apparatus which operated on both buildings. Ladders 79 & 80 took positions to operate on exposure 2 and members of those units began to ventilate, extricate, and search exposure 2.

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Engine 163 arrived at 1438 hours and stopped at the hydrant approximately 300 feet south of the fire building. Crew members, including the victim, donned their personal protective equipment (PPE) and proceeded toward the command post. PPE consisted of turnout pants, turnout jacket, helmet, boots, gloves, and a self contained breathing apparatus (SCBA). The entire ensemble weighed approximately 60 pounds. The air temperature was 88° Fahrenheit with a humidity of 39 percent, and a wind of 12 miles per hour from the west.

The victim was assigned as the backup position for the nozzleman. While walking toward the command post, they moved/repositioned the uncharged 3½ inch hose connecting Engine 157 to its second hydrant. A few minutes later, without notifying his nozzleman, the victim return to Engine 163. According to a civilian witness, the victim was very short of breath and entered the crew cab door on the driver's side of the Engine.

Crewmembers of Engine 163 were assisting with the hooking up and positioning of hoses in front of the fire building, when their Officer noted one of his fire fighters missing. He ordered the nozzleman, the victim's Backup/partner, to search the immediate area. After a few minutes of looking and asking other fire fighters in the area, the victim could not be located. The Officer ordered him to search a wider area and relayed this information to the Deputy Chief. At approximately 1449 hours, the Deputy Chief gave a "Mayday" order over the portable radio, ordered that channel to be kept clear, and initiated procedures for a missing member. This included ordering every on-scene unit to conduct a roll call of their members.

While this was being conducted, the FAST Truck (Ladder 78) arrived on-scene. The Deputy Chief ordered them to search for the victim in Exposure 2. At this time Engine 163's Driver/Operator (Chauffeur) returned to his apparatus for repositioning. After moving the Engine about 75 feet closer to the fire building, he noticed the victim in the L1 riding position. The victim was unresponsive with his helmet on and air mask off. His PASS (Personal Alert Safety System) was not emitting an alarm signal. The PASS device employed by this FD is integrated into its SCBA. Since the victim and other fire fighters in his company had not turned on their air yet, the PASS device was not yet activated. The Driver entered the crew cab to shake the victim who remained unresponsive at which point the Driver used a portable radio to notify the Deputy Chief that he had located the missing fire fighter and that he was unresponsive. The Driver, with assistance from an off-duty police officer, pulled the victim from the apparatus.

The EMS unit (Unit 22B2) had positioned itself close to Engine 163 anticipating that, once found, the victim would need medical assistance. Once out of the cab, the victim was re-assessed by the EMS unit who noted he was unresponsive with no pulse and no spontaneous respirations at approximately 1452 hours. CPR was initiated, an oral airway inserted and oxygen was administered via a bag-valve-mask. A heart monitor was attached to the victim which did not find a shockable heart rhythm. CPR was continued as the victim was placed on a stretcher and loaded into the ambulance for transport to the nearest hospital. The ambulance departed the fire scene at 1457 hours and arrived at the hospital emergency department at 1500 hours.

Once in the hospital emergency department CPR and ALS continued for an additional 27 minutes. At 1527 hours, the victim was pronounced dead and resuscitation measures were discontinued.

Medical Findings. The death certificate, completed by the First Deputy Chief Medical Examiner, listed "hypertrophic cardiomyopathy with myocardial arteriolarsclerosis" as the cause of death with a

"myxomatous" mitral valve" as a contribution cause of death. The First Deputy Chief Medical Examiner also conducted the autopsy. Pertinent findings included:

- Widely patent (open) coronary arteries;
- An enlarged heart weighing 440 grams (normal less than 400 grams);
- Slightly thickened left ventricle of 1.4 centimeters (cm) in diameter (normal <1.3)
- Microscopic changes of the heart muscle
- Myocyte bundles arranged in a sinusoidal and other irregular patterns
- Focal myocyte hypertrophy with occasional multipolarity
- Widened interstitium with fibrosis in irregular patterns
- Arterioles with thickened intima
- No inflammatory infiltrates, contraction banding, or hypereosinophilia
- Marked billowing of both leaflets of the mitral valve;
- No evidence of a blood clot (embolus) in the pulmonary arteries;
- His blood carboxyhemoglobin level was less than 3%, suggesting the victim was not exposed to excessive carbon monoxide levels.

The candidate had a history of a heart murmur and in 1998 had an echocardiogram. This test showed mitral valve prolapse (MVP) with mild regurgitation. Since that time he denied any palpitations, dizziness, being lightheaded, syncope, shortness of breath, shortness of breath on exertion, or chest pain. In October 2000, the FD's pre-placement medical evaluation identified his heart murmur and a resting electrocardiogram showed "supraventricular extrasystoles." These findings prompted the FD to required the Candidate to undergo an exercise stress test (EST) and another echocardiogram. The echocardiogram confirmed his MVP with mild regurgitation which was unchanged from 1998 with normal left ventricular size and function. For the EST, he exercised for 15 minutes (Stage V of the Bruce protocol), reaching a heart rate of 173 beats per minute (88% of his maximum target heart rate). This test showed excellent exercise tolerance, normal blood pressure response, no symptoms, and no electrocardiographic evidence of ischemia, or arrhythmias. With these tests completed, the FD's medical staff cleared the Candidate for full duty as a fire fighter.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the Fire Fighter's death, the FD consisted of approximately 11,000 Uniformed Fire Fighters and Fire Officers, 270 Fire Inspectors, 230 Fire Marshals, and 1,600 administrative support personnel serving a population of eight million residents, in a geographic area of 322 square miles. There are over 300 fire stations and buildings. The emergency medical services have operated as a function of the FD since 1996. Fire fighters work the following shifts: Day 1 & 2: 9am to 6pm; Day 3: off; Day 4&5: 6pm to 9am; Day 6-8: off.

In 2001, the FD responded to 27,788 structural fires, 29,655 non-structural fires, 172,638 non-fire emergencies, 155,396 medical emergencies, and 51,544 malicious false alarms. The EMS units of the FD made 1,281,977 runs to 1,097,564 incidents. The number of runs exceeds the number of incidents because more than one unit can be dispatched to a single incident. Prior to the incident, the victim was on duty for approximately 5 hours and had responded to two calls.

Training. The FD requires newly hired fire fighters to attend a 12-week training program at the Division of Training, after which they are certified fire fighter NFPA level I. This training includes certification as a first responder which includes CPR and certification

for the use of the automated external defibrillator. In February 2001, the victim was hired as a probationary fire fighter. In July, 2001 he graduated from the Fire Department's training academy and was assigned to Engine company 163.

Pre-employment/Pre-placement Evaluations. Fire fighter candidates are required to complete a physical ability test at the time of their application. The test used by this FD is very similar to the Candidate Physical Ability Test developed jointly by the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC).[1] All qualified Candidates are put on a hiring list. As positions in the FD become available, applicants are brought into the FD's Health Services Department for a pre-placement medical evaluation. Components of the pre-employment/pre-placement evaluation for all applicants include:

- A complete medical history and questionnaire
- Height, weight, and vital signs
- Physical examination
- Vision test
- Hearing test
- Blood tests: Complete blood count, chemistry panel (SMA 20) which includes a cholesterol and triglyceride measurement
- Urinalysis
- Urine drug test
- Spirometry (lung function tests)
- Resting electrocardiogram
- Chest X-ray
- Skin test for tuberculosis (PPD)
- Immunizations administered if proof of vaccination cannot be provided [hepatitis B, measles, mumps, & rubella (MMR), tetanus if a booster had not been given within the past ten years]
- Fire Fighters assigned to waterways also are offered a hepatitis A vaccine.

These evaluations are performed by the FD Medical staff, who make a decision regarding medical clearance for fire fighting duties. This medical evaluation also consist of a physical fitness and strength test. The aerobic/fitness component of this test involves three minutes on a Stairmaster operating at 60 steps per minute with the new hire wearing a sixty-pound vest. An EKG is not taken, but the heart rate is recorded with a target being less than 90% of their maximum (220 minus age).

Periodic Evaluations. Since 1998, periodic medical evaluations have been required by this FD for **all** fire fighters. The goal has been to conduct these on an annual basis, but logistical problems have resulted in their being conducted approximately every 15 months. Components of this evaluation are identical to the pre-employment evaluation with three exceptions: the chest X-ray is required only every three years, 2) the drug screen is not required, 3) and the aerobic fitness test does not include a 60-pound pack and the target heart rate is 85% of the member's maximum. The victim's last medical evaluation was conducted by the FD as part of his pre-placement medical examination. As described earlier, this was conducted in October, 2000 and he was cleared for full duty by the FD's Health Services Department.

Medical Clearance, and Fitness/Wellness Programs. If a fire fighter is injured at work must be evaluated and cleared for "return to work" by a physician in the FD's Health Services Department. A fire fighter who misses work for one or more days because of a illness (work-related or not), must also be evaluated and cleared for "return to work" by the FD medical staff.

All fire houses have exercise (strength and aerobic) equipment, some purchased by the fire fighters themselves. There are voluntary smoking cessation and weight control programs, and a voluntary

wellness/fitness program similar in content to the IAFF/IAFC wellness/fitness initiative.[2]

DISCUSSION

Prior to becoming a fire fighter, the deceased was diagnosed with mitral valve prolapse (MVP). MVP is a relatively common heart condition, effecting approximately 2.4% of the population.[3] The majority of patients with MVP are asymptomatic, however non-specific symptoms (fatigue, palpitations, chest pain) can occur.[4] In patients with more severe MVP, such as significant valvular regurgitation, symptoms of reduced cardiac reserve (e.g. fatigue, shortness of breath on exertion, and reduce exercise tolerance) are typically present.[5] The diagnosis of MVP is made by echocardiography where the abrupt posterior movement of one or both of the mitral value leaflets during systole can be measured.[6] Usual pathology findings are the "myxomatous proliferation" of the mitral valve (middle layer of the valve leaflet is composed of loose material).[7] MVP patients are at slight increased risk of sudden cardiac death, but this is probably limited to cases with symptoms (history of syncope and palpitations), complex ventricular arrhythmias, or severe mitral regurgitation.[8,9]

On autopsy the deceased fire fighter was also found to have hypertrophic cardiomyopathy (HCM). This was suggested by the non-specific findings of a large heart (440 grams) and slightly thickened left ventricle (1.4 centimeters), and confirmed by the microscopic changes found in the heart muscle (focal hypertrophy with an irregular muscle bundles).[10] HCM is a relatively rare heart condition, effecting approximately 0.2% of the population.[11] The majority of patients are asymptomatic, however, unlike MVP, sudden cardiac death is often its first clinical manifestation, particularly among patients less than 30 years of age.[12] Sudden cardiac death in HCM patients is probably due to ventricular arrhythmias. Since myocardial ischemia is a common finding in HCM, these ventricular arrhythmias could be triggered by myocardial ischemia.[12] Risk factors for sudden death among HCM patients include young age (<30 years old) at diagnosis, a family history of HCM with sudden death, an abnormal blood pressure response to exercise, severe symptoms, non-sustained ventricular tachycardia, marked hypertrophy, marked left atrial dilatation, and genetic abnormalities associated with increased prevalence of a sudden death.[11-13]

Approximately half of the HCM cases are transmitted genetically, typically in an autosomal dominant trait with disease loci on at least eight different chromosomes.[14] Unfortunately, genetic testing is not routinely available and remains largely a research tool. The causes of HCM in the other half of patients is unknown.[12] The victim's family is aware that of the familial distribution (inherited pattern) of this condition, and have taken steps to have family members medically evaluated.

This fire fighter had classic mild MVP (asymptomatic, only mild mitral regurgitation, no evidence of left ventricular dysfunction), and did not have any of the MVP risk factors for sudden cardiac death. Therefore, it is unlikely, his sudden death was associated with his MVP. The victim's sudden death is more likely associated with his HCM. Although he had only one of the risk factors for HCM related sudden death, sudden cardiac death is a well-known association and often the first clinical manifestation of HCM, particularly in young individuals. It is important to note that candidates without heart murmurs do NOT get the extensive cardiac work-up this FD required. Despite getting a pre-placement EST and an echocardiogram nine months prior to his death, his underlying HCM went undetected. This was probably due to the very early and mild status of his HCM.

Had the victim's HCM been identified during the fire department's preplacement evaluation, would he have been denied employment as a fire fighter? HCM is not specifically addressed in the NFPA 1582 (*Medical Requirements for Fire Fighters and Information for Fire Department Physicians*.)[15] However, it would most likely be considered a Category B Medical Condition, 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." Despite the victim's absence of symptoms, excellent exercise tolerance, normal EST, and unremarkable echocardiography, if his HCM was identified the FD may have been denied employment. It is unclear, however, if this would have withstood a challenge by the Candidate under the Americans with Disabilities Act.

Had the victim's HCM been identified, would this have prevented his death? Although a variety of symptoms and medical tests can provide prognostic information, patients at greatest risk of sudden death or in need of antiarrhythmic therapy are hard to identify. Given the victim's absence of the above mentioned risk factors for sudden death, the low degree of efficacy of anti-arrhythmic agents and their numerous side effects, and the lack of symptoms in this fire fighter, it is unlikely that a diagnosis would have lead to treatment. Therefore, it is unlikely his tragic sudden death would have been prevented even if his condition was discovered.

Most sudden cardiac arrests are due to ventricular fibrillation, an irregular heat rhythm that cannot sustain life. CPR provides some circulation of oxygen-rich blood to the victim's heart and brain, but it only buys time until the heart can be defibrillated (shocked). Defibrillation can restore the heart's normal rhythm if it's done within minutes of the arrest. Each minute of delay, however, decreases the victim's chance of survival by 7% to 10%.[16] The combination of late CPR (more than 4 minutes) and late advanced life support (more than 12 minutes) is particularly lethal.[16] Several researchers have called these time dimensions the resuscitation "failure zone."[16] For five to ten minutes, the victim could not be found at the fire ground. While early defibrillation could not guarantee his survival, its delay precluded it.

Had this fire fighter notified his superiors that he was returning to his rig, this would have reduced the time to defibrillation. Similarly, if his crew members noted his returning to the rig, this would probably have reduced the time to defibrillation. Thus, fire fighters need to recognize the importance of any unusual symptoms, report these symptoms to their officers, and inform their co-workers and superiors about their intentions to relocate. Likewise, crew members need to maintain constant contact with their assigned "buddy." Since both these issues were problems during this incident, future training sessions should re-emphasize the importance of fire ground communication and fire ground accountability.

Personal Alert Safety Systems (PASS) devices have been developed to emit an audible alarm signal to summon aid in the event the PASS user becomes incapacitated or needs assistance. NFPA 1982 [*Standard on Personal Alert Safety Systems (PASS)*] requires the device to have three modes (*off*, *alarm*, and *sensing*), and an automatic activation from the *off* mode to the *sensing* mode with the user setting the mode characteristics.[17,18] The are many ways in which this automatic activation can be achieved: SCBA integrated, linked to storage or transportation positions, pull-away tethers attached to a fixed position, remote activation. This FD has selected and purchased the SCBA integrated devices. When found, the victim was wearing his SCBA but the air was off and thus the PASS device was not activated. While other types of automatic

activation would have activated in this situation, they have significant drawbacks. Because of these drawbacks, the SCBA-Integrated PASS is considered the most advanced, and desirable systems. Therefore, we do not recommend the FD change their PASS devices.

RECOMMENDATIONS

A number of agencies have developed preventive measures to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. This strategy consists of: 1) minimizing physical stress on fire fighters; 2) screening to identify and subsequently rehabilitate high risk individuals; and 3) encouraging increased individual physical capacity. This strategy has not been evaluated by NIOSH, but represents research presented in the literature, consensus votes of Technical Committees of the NFPA, or labor/management groups within the fire service. Unfortunately most, if not all, of these measures are already being followed by this FD. Therefore, it is unlikely the Fire Department could have prevented this fire fighter's untimely death. Nonetheless, potentially relevant issues applicable to this FD include:

Recommendation #1: Emphasize the importance of communication and accountability on the fire ground, particular to fire fighters with minimal fire ground experience.

Fire fighting requires a high level of physical exertion, therefore fire fighters frequently experience shortness of breath. However, given this fire fighter's excellent aerobic condition (as demonstrated during his EST in 2000), and that he had yet to engage in severe physical exertion, his shortness of breath seemed out of proportion with his fire ground activity. Therefore, he probably should have notified crewmembers of two things: a) his symptoms, and b) that he was returning to the rig. Not communicating this information to his crew resulted in an approximately five to ten minute delay in locating the victim. The delay reduced his opportunity for survival. We recommend the Fire Department re-examine their training programs to ensure fire ground communication and accountability are emphazised.

Recommendation #2: Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by emphasizing the Fire Department's mandatory wellness/fitness program.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, and NFPA 1583, *Standard on Health-Related Fitness Programs for Fire Fighters*, require a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[19,20] In 1997, the IAFF and the IAFC published a comprehensive *Fire Service Joint Labor Management Wellness/Fitness Initiative* to maintain physical and mental capabilities of fire fighters, prevent health problems, and enhance their overall well-being.[2] Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.[21-23] A similar cost savings has been reported by the wellness program at the Phoenix FD, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.[24]

This FD has developed a voluntary fitness/wellness program similar to those described above. However, some aspects of the program are incorporated into the mandatory annual medical evaluation (e.g. smoking cessation, diet, fitness tests, etc). Other aspects of the fitness/wellness program are offered on a voluntary basis. Short of requiring a mandatory program, efforts should be made to increase fire fighter participation. This could be accomplished by giving units "protected time" or taking units out of service for fitness training.

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INVESTIGATOR INFORMATION

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