



## **Volunteer Fire Fighter Suffers Cardiac Death the Morning After Emergency Medical Technician Training – North Carolina**

### **SUMMARY**

On January 8, 2005, a 26-year-old male volunteer Fire Fighter (FF) completed Emergency Medical Technician (EMT) training and returned home. The next morning the FF's wife was awakened by his agonal (gasp) breathing. After being unable to wake him, she notified Emergency Medical System (EMS) who arrived to find the FF unresponsive with no pulse, and no respirations. Cardiopulmonary resuscitation (CPR) was begun and a cardiac monitor showed the FF was in ventricular fibrillation (VF). He was shocked (defibrillated) multiple times followed by advanced life support (ALS) medications until his rhythm changed to pulseless electrical activity. During transport to the local hospital, the FF received an external pacemaker and further ALS measures. Approximately 55 minutes later, despite CPR and ALS administered on the scene, in the ambulance, and at the hospital, the FF died. The autopsy revealed mitral valve prolapse with cardiomegaly. The death certificate, completed by the county medical examiner, listed mitral valve failure as the cause of death.

It is unlikely the following recommendations could have prevented the FF's death. Nonetheless, the NIOSH investigators offer these recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters.

- *Provide mandatory pre-placement and annual medical evaluations to ALL fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.*
- *Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective*

*equipment used by fire fighters, and the various components of NFPA 1582, Standard on Comprehensive Occupational Medicine Program for Fire Departments.*

- *Provide fire fighters with medical clearance to wear self-contained breathing apparatus (SCBA).*
- *Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.*
- *Perform an annual physical performance (physical ability) evaluation to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting.*

### **INTRODUCTION & METHODS**

On January 9, 2005, a 26-year-old male fire fighter suffered a sudden cardiac death at home approximately 12 hours after completing EMT training. On January 13, 2005, NIOSH contacted the affected fire

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/fire](http://www.cdc.gov/niosh/fire) or call toll free 1-800-35-NIOSH



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department (FD). On August 8, 2005, an Occupational Health Nurse Practitioner from the NIOSH Fire Fighter Fatality Investigation Team traveled to North Carolina to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed the following people:

- Fire Chief
- Fire fighter's wife
- State Fire Marshal's Investigator

During the site visit NIOSH personnel reviewed the following documents:

- FD policies and operating guidelines
- FD training records
- FD annual report for 2004
- FD incident report
- Ambulance response report
- Hospital records
- Medical records
- Autopsy results
- Death certificate
- Witness statements

## **INVESTIGATIVE RESULTS**

*Incident.* In the evening of January 8, 2005, a 26-year-old male volunteer FF attended 2 hours of EMT training. This training was part of the EMS physical assessment class governed by state guidelines. The training exercise requires positioning and moving a 150-pound mannequin, which involves moderate exertion. The FF returned to his home (where he did no further physical activity) shortly after the end of the exercise. The fire fighter's classmates and wife state that he did not complain of any discomfort or signs and symptoms of distress before going to bed at approximately midnight.

The next morning, at approximately 0550 hours, the FF's wife was awakened by his agonal (gasp)

breathing. After trying to get the FF breathing again, she ran to a next door neighbor's house for help. The neighbor's wife activated the EMS system at 0557 hours and called additional neighbors. The neighbors arrived at the FF's house at 0559 hours and found the FF on the floor beside the bed with no respirations or pulse. They performed CPR until the ambulance arrived with two EMT-paramedics (EMT-P) at 0609 hours.

The EMT-Ps found the FF unresponsive with no pulse or respirations and cyanosis forming from mid-chest to face. They initiated ALS protocol, which included connecting the FF to a heart monitor. Simultaneously, intubation was performed (correct placement confirmed using a secondary technological test [bulb method]), and an intravenous line was established. The FF's heart rhythm was found to be in VF (a rhythm incompatible with life). The FF was given a precordial thump and shocked three times. The EMT-Ps alternated ALS medications and defibrillations until the rhythm changed to pulseless electrical activity. At 0629 hours the EMT-Ps loaded the FF into the ambulance and departed the scene. Enroute they continued ALS measures complete with an external cardiac pacemaker (it failed to capture) until they arrived at the local hospital's emergency department (ED) at 0646 hours (hospital records state arrival was 0648 hours). ED personnel found the FF cyanotic, with no heart beat (asystole). After the ED physician heard the EMS report, including that the FF had no effective heart beat for at least 46 minutes, treatment was ordered discontinued and the FF was pronounced dead at 0652 hours.

*Medical Findings.* The death certificate, completed by the Medical Examiner, listed "mitral valve failure" as the immediate cause of death. An autopsy was performed by the Medical Examiner. Significant findings were as follows:

- Mitral valve prolapse - undulating leaflets with obvious hooding and thin, elongated chordae tendineae consistent with prolapse



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- Cardiomegaly - (530 grams, normal < 400 grams) with mild left ventricular hypertrophy – left ventricle thickness 1.4 cm (normal .6-1.1 cm), interventricular septum 1.6 cm (normal .6-1.1 cm)
- Microscopic examination of the heart muscle showed widening of the individual myocytes and large, irregular, “boxcar” nuclei; focal increased interstitial fibrosis was present within the posterior left ventricle
- Widely patent coronary arteries without evidence of significant atherosclerosis or thrombosis

The fire fighter had no history of a cardiac dysfunction. His body mass index was 23.6 kilograms/meter<sup>2</sup> (normal).<sup>1</sup> His most recent blood pressure (taken in his primary care physician’s office, July 12, 2004) was 127/73 millimeters of mercury. In October 2004, the FF had knee surgery requiring general anesthesia. A cardiovascular system evaluation performed by the anesthesiologist was negative for findings. In January 2003, the FF was cleared for a commercial driver’s license at an occupational health clinic. According to family and fire department personnel, the FF never exercised. He had expressed no signs or symptoms of chest pain, shortness of breath, or any other discomfort to his wife, co-workers, or health care providers prior to this incident. He had no family history of cardiac disease.

## DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the FD was an all-volunteer department consisting of 26 fire fighters. Its two fire stations served a population of 5,000 in a geographic area of 5 square miles.

In 2004, the FD responded to 147 calls: 50 fires, 45 rescue and medical calls, 3 hazardous condition calls, 28 false alarm/good intent calls, 2 service calls, and 19 other calls and incidents.

*Training.* The FD requires all new volunteer fire fighter applicants to complete an application and an interview with the Fire Chief. The FD members then vote to accept or reject the applicant. Accepted applicants must attend a state fire course that certifies the equivalent of Fire Fighter I. Once they have successfully passed this course, new applicants are allowed to perform interior fire attack. The FF was trained in apparatus operation, first aid/CPR, and live fire training but he was not a state-certified Fire Fighter I. He had 4 years of volunteer fire experience, but less than 2 years with this FD.

*Pre-placement Medical Evaluations.* The FD does not require a pre-placement medical evaluation.

*Periodic Medical Evaluations.* The FD does not require periodic medical evaluations. Fire fighters are encouraged to receive a complete physical examination through their employer or at their own expense and provide a release form to the department. Medical clearance for SCBA use is not required. FFs injured while volunteering are evaluated by and must be cleared for return by their personal physician. The FF’s last medical examination occurred approximately 3 months before he died (as described earlier).

*Fitness/Wellness Programs.* No wellness/fitness programs are available. No aerobic or strength training equipment is available at the stations.

## DISCUSSION

The autopsy revealed no coronary artery disease (CAD) and no thrombus (blood clot in any of the coronary arteries); therefore, the FF did not suffer a heart attack (myocardial infarction). The autopsy revealed abnormalities consistent with mitral valve prolapse (MVP).

*Mitral Valve Prolapse Syndrome.* MVP syndrome is “a variable clinical syndrome that results from diverse pathogenic mechanisms of one or more portions of the



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mitral valve (e.g., mitral valve apparatus, valve leaflets, chordae tendineae, papillary muscle, and valve annulus).”<sup>2</sup> It is the most common valve dysfunction, affecting 2.4% of the population.<sup>3</sup> Some cases of MVP are associated with the following conditions:

1. rare inheritable disorders of connective tissue (e.g., Marfan syndrome, Ehlers-Danlos syndrome, osteogenesis imperfecta, pseudoxanthoma elasticum, periarteritis nodosa, myotonic dystrophy, von Willebrand disease)
2. congenital malformations (e.g., Ebstein anomaly of the tricuspid valve, atrial septal defect of the ostium secundum variety, the Holt-Oram syndrome)
3. hypertrophic cardiomyopathy

The MVP syndrome appears to exhibit a strong hereditary component, and in some patients is transmitted as an autosomal dominant trait with varying penetrance.<sup>2</sup>

Most patients with MVP are asymptomatic, however non-specific symptoms (fatigue, palpitations, chest pain) can occur.<sup>4</sup> In patients with severe MVP, symptoms of reduced cardiac reserve (e.g., fatigue, shortness of breath on exertion, and reduced exercise tolerance) are typically present.<sup>4</sup> The diagnosis of MVP is suggested by a heart murmur and confirmed by an echocardiogram (ECG) where the abrupt posterior movement of one or both of the mitral valve leaflets during systole can be measured.<sup>5</sup> The ECG is usually normal in asymptomatic patients with MVP. Usual pathology findings are the “myxomatous proliferation” of the mitral valve (middle layer of the valve leaflet is composed of loose material).<sup>6</sup>

A variety of arrhythmias have been observed in MVP patients. These arrhythmias include atrial and ventricular premature contractions, supra-ventricular and ventricular tachyarrhythmias, and bradyarrhythmias due to sinus node dysfunction or varying degrees of atrioventricular block.<sup>2</sup> MVP

patients may be at a slight increased risk of sudden cardiac death due to these arrhythmias. However, this increased risk is probably limited to cases with symptoms (history of syncope and palpitations), complex ventricular arrhythmias, or severe mitral regurgitation.<sup>7,8</sup> Sudden cardiac death in MVP patients is reported to be <1% per year.<sup>9</sup> Although this FF was asymptomatic, his autopsy showed severe mitral valve pathology.

Over the past 18 months this FF received multiple examinations by at least four different physicians. This included pre-operative examinations by an anesthesiologist and an orthopedic surgeon, a commercial driver’s license physical examination consistent with the U.S. Department of Transportation guidelines performed by an occupational medicine physician, and normal check-ups with his primary care physician. A physical was performed as recently as 3 months prior to his death. Given the FF’s severe degree of MV pathology at autopsy, it is unclear why no heart murmur was detected. Possibilities include that his murmur was either too faint to be identified, his condition significantly worsened in the 3 months prior to his death, or the examining physician(s) missed the heart murmur.

Fire fighters work in environments immediately dangerous to life and health (IDLH). Therefore, if fire fighters become suddenly incapacitated, not only are their own lives endangered, but also those of their peers and the civilians they have sworn to protect. To assist physicians making medical clearance decisions, the NFPA developed 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments*.<sup>10</sup> According to the NFPA 1582, MVP only interferes with safety if arrhythmias of moderate to severe regurgitation occur. Physical examinations are the optimal diagnosing method, followed by echocardiography as necessary with leaflet thickness as the gauge of severity. Even with a diagnosis of MVP, it is difficult to state whether impairment would have been recognized as severe enough to restrict duties and possibly prevent his death.



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*Left ventricular hypertrophy.* On autopsy the deceased fire fighter was also found to have left ventricular hypertrophy (LVH). Hypertrophy of the heart's left ventricle is a relatively common finding among individuals with long-standing high blood pressure (hypertension), a heart valve problem, or chronic cardiac ischemia (reduced blood supply to the heart muscle). The FF was never diagnosed with high blood pressure, and he did not have ischemic CAD. Therefore, his LVH was likely due to mitral valve abnormality.

## RECOMMENDATIONS

It is unlikely the following recommendations could have prevented the FF's death. Nonetheless, the NIOSH investigators offer these recommendations to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters.

***Recommendation #1: Provide mandatory pre-placement and annual medical evaluations to ALL fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments<sup>10</sup> to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***

Guidance regarding the content and frequency of pre-placement and periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582 and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.<sup>11</sup> The Department is not legally required to follow any of these standards.

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) provide permanent alternate duty positions or other supportive and/or compensated alternatives if the fire fighter is not medically qualified to return to active fire fighting duties.**

***Recommendation #2: Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582, Standard on Comprehensive Occupational Medicine Program for Fire Departments.***

Physicians who provide input regarding medical clearance for fire fighting duties should be knowledgeable about the physical demands of fire fighting and understand that fire fighters frequently respond to incidents in IDLH environments. They should also be familiar with a FF's personal protective equipment and the consensus guidelines published by NFPA 1582, *Standard on Comprehensive Occupational Medicine Program for Fire Departments*.<sup>10</sup> To ensure physicians are aware of these guidelines, we recommend that the FD or the FF provide the personal physicians with a copy of NFPA 1582.

We also recommend the FD retain a "fire department physician" to review all medical clearances, and not necessarily "rubber stamp" the opinions of specialists or other treating physicians regarding return to work. This decision requires knowledge not only of the medical condition, but also of the fire fighter's job duties. Personal physicians may not be familiar with a FF's job duties, or with guidance documents such as NFPA 1582. In addition, they may consider themselves patient advocates and dismiss the potential public health impact of public safety officials who may be suddenly incapacitated. Therefore, we recommend that a "FD physician" who has the final decision regarding medical clearance review all return-to-work clearances.



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***Recommendation #3: Provide fire fighters with clearance to wear self-contained breathing apparatus (SCBA) as part of the Fire Department's medical evaluation program.***

OSHA's Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection.<sup>12</sup> These clearance evaluations are required for private industry employees and public employees in states operating OSHA-approved State plans. North Carolina does operate an OSHA-approved State plan, therefore, public sector employers are required to comply with OSHA standards. Therefore, we recommend following this standard.

***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 Programs*, requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.<sup>13</sup> The IAFF and the 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.<sup>11</sup> Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.<sup>14,15</sup> 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 disability pension costs.<sup>16</sup>

In January 2004, the National Volunteer Fire Council and US Fire Administration published a comprehensive manual, *Health and Wellness Guide for the Volunteer Fire Service*.<sup>17</sup> The guide provides suggestions for program initiation and features. This guide is useful for not only volunteer fire departments, but also small combination fire departments that could benefit from some type of fitness and wellness program. The FD should implement this recommendation to ensure coronary artery disease (CAD) risk factors are reduced and cardiovascular capacity is increased.

***Recommendation #5: Perform an annual physical performance (physical ability) evaluation for ALL fire fighters to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting.***

NFPA 1500 requires fire department members who engage in emergency operations to be annually evaluated and certified by the fire department as meeting the physical performance requirements identified in paragraph 8-2.1.<sup>13</sup>

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