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46-year-old Motor Pump Operator Collapses During Residential Fire Response and Dies – Connecticut

Executive Summary

On December 26, 2022, at about 0100 hours, a 46-year-old motor pump operator/engine driver (MPO) was dispatched with his crew to a residential fire with occupants trapped inside. On arrival at the location, the MPO was assigned to provide support from the building exterior, operating the truck in the extreme cold (below freezing) conditions. When he noticed interior crews having difficulty advancing a hoseline inside, he took the initiative and left the pump panel to assist by pushing the hoseline from the outside and assisted with hose advancement up to the second-floor landing because the firefighter at the nozzle was advancing the line solo up to the third floor. The second-floor landing was not considered to be an IDLH atmosphere (immediately dangerous to life or health). One of his crew members asked the MPO to assist with changing out his self-contained breathing apparatus (SCBA) bottle. They walked back to the engine to do so. The MPO was standing at the engine's pump panel when he collapsed.

The crew member he was assisting, who was also a paramedic, witnessed the MPO collapse to the ground. His initial assessment found the MPO to be unresponsive and pulseless. This crew member called a Mayday, and he and a firefighter from a rescue unit immediately initiated cardiopulmonary resuscitation (CPR). An advanced life support transport unit that was on the scene transported the MPO to the nearest emergency department. Resuscitation was unsuccessful. The MPO was declared dead at 0227 hours. The medical examiner found the death due to hypertensive and cardiovascular disease, with obesity and a bicuspid aortic valve as contributing factors. Connecticut Occupational Safety and Health (CT OSHA) conducted an investigation and in a letter dated April 13, 2023, determined there were no violations of OSHA standards involved in this incident, and no citations were issued.

Key Recommendations

NIOSH offers the following recommendations to reduce the risk of adverse cardiac events among firefighters at this and other fire rescue agencies across the country.

- *Key Recommendation #1: Consider requiring annual medical evaluations. Although annual medical evaluations are not required by department policy, NFPA 1582 recommends annual medical evaluations of members [NFPA 2022].*

Please note that although NFPA standards are updated periodically, it is our practice to cite the version in effect at the time of the fatality. In 2025, the NFPA consolidated standards 1581–1584 that we cite in this report into a single 1580 standard.

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- *Key Recommendation #2: Consider providing NFPA educational material to the healthcare providers performing Respiratory Questionnaire Health Surveillance Records (also known as Respiratory Clearance Medical Evaluations). Include information on essential job tasks requiring respiratory protection as well as NFPA clearance guidelines for specific medical conditions [NFPA 2022].*

- *Key Recommendation #3: Reinforce education among firefighters, including fire academy trainees, that developing new medical conditions after beginning a career in the fire service can happen and is accounted for in NFPA 1582. This standard is focused on ensuring that firefighters with various medical conditions can safely perform their essential job tasks while receiving the appropriate medical care for those conditions [NFPA 2024].*

- *Key Recommendation #4: Encourage all Fire Department (FD) members to seek prompt medical care for new symptoms and medical concerns. Recommend that all members obtain a primary care provider regardless of any required FD annual medical evaluation. Having an existing relationship with a healthcare provider can enable discussion and management of new health issues as they arise.*

- *Key Recommendation #5: As required by OSHA's Respirator Standard, a Respiratory Clearance Medical Examination should precede each annual Respirator Certification (fit test). Consider creating a consolidated file management system to ensure this is occurring and provide easy access to past records.*

- *Key Recommendation #6: Assess emergency incident documentation procedures and consider consolidating emergency medical services and FD call records.*

- *Key Recommendation #7: Review FD Mayday call protocol with the dispatch office to ensure understanding and compliance to FD standard operating procedures. Dispatchers often operate from a controlled environment, such as an office or control center. They need to be familiar with fire rescue terminology to know how to best support the agencies they serve. This may include creating timers, assisting with notifications, and capturing any difficult to hear radio transmissions using a playback feature. Ensuring radio discipline is essential during these high-stress incidents.*

For further information, visit the program website at www.cdc.gov/niosh/firefighters/fffipp/about.html or call toll free 1-800-CDC-INFO (1-800-232-4636).

Introduction

On December 26, 2022, a 46-year-old motor pump operator/engine driver (MPO) collapsed while participating in fire suppression at a residential fire and died shortly after arriving at local Emergency Department. The U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this fatality through its firefighter fatality email notification service. NIOSH contacted the affected fire department (FD) to gather additional information and initiate the investigation.

A medical officer and a firefighter safety specialist with the NIOSH Fire Fighter Fatality Investigation and Prevention Program (FFFIPP) conducted the investigation. NIOSH staff conducted a site visit May 24–26, 2023.

During the investigation, the NIOSH investigators interviewed the following people:

- *FD Chief*
- *Emergency Department (ED) Physician and ED code scribe nurse*
- *The MPO's mother and spouse*
- *FD-appointed family liaison/firefighter who worked with the MPO*

The NIOSH investigators reviewed the following documents:

- *FD incident narrative report*
- *Records from the MPO's Primary Care Provider (PCP) and cardiologist*
- *Respiratory Questionnaire Health Surveillance Records and Respirator Certifications*
- *ED records*
- *Medical examiner's report*

Fire Department

At the time of the NOSH investigation, this FD consisted of over 40 career firefighters staffed at two stations, with about 20 volunteer firefighters staffed at an additional two stations. The FD's average call volume is 4,300–5,200 calls per year. Of these, around 55% are medical, 40% fire incidents, and 5% motor vehicle accidents. The FD participates in a mutual aid response team with surrounding towns.

Membership and Training

The MPO had been an FD member for 21.5 years. He started in 1996 as a volunteer and was hired in July 2000 as a paid crew member. He was state certified as a pump operator, aerial operator,

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emergency medical technician, hazmat technician, and fire arson investigator. At the time of his death, he was a pump operator and driver for the department.

On December 14, 2000, the MPO completed 5 months of training at the state fire academy. The local fire commission must vote on and approve selection of newly hired firefighters. This vote for the MPO occurred on July 27, 2000. The MPO was recognized in 2001 for his service as a responder to the World Trade Center disaster where he participated in the rescue efforts, including entry into one of the towers. On September 13, 2004, he became a qualified pump operator.

Preplacement/Periodic/Return to Work Medical Evaluations

This FD's preplacement medical evaluation includes an electrocardiogram (EKG), a physical examination, and four tests: audiometry, EKG stress test, pulmonary function, and urine test for illicit drugs. The MPO completed these August 2–10, 2000, which was at the start of his state fire academy course.

On August 2, 2000, a cardiologist report stated these results of the MPO's exercise stress test (EST): the MPO achieved 14 METS during the 13-minute test with no chest pain and normal EKG. One method to estimate the amount of energy used in various physical activities involves the use of a quantity called the metabolic equivalent of task (MET). "The MET estimates the amount of oxygen used by the body during physical activity. The harder the body works, the higher the MET" [CDC 2023]. In the "Past Medical History Questionnaire for Employment" form, also dated August 2, 2000, a physician reported the results of the MPO's medical evaluation. That doctor noted that the MPO had no medical or surgical history, had no known medication allergies, and was not on any medication at the time. The MPO was reported to be 69 inches (5′9″) and 250 pounds, resulting in a body mass index (BMI) of 36.9 kg/m^2. BMI is a measure of body weight relative to height and is calculated by the formula: weight (kg)/ height (m^2) [CDC 2024a]. The physical exam was unremarkable with normal blood pressure at 120/76 mmHg and a resting heart rate of 80 beats per minute (bpm). His urine dipstick was negative, and his EKG "showed normal sinus rhythm without any acute or ischemic changes." He had normal visual acuity, audiogram results, and pulmonary function testing (PFT) results.

The OSHA Respirator Standard requires fit testing prior to initial respirator use and then annually as long as the respirator is required [OSHA 2006]. The results of the required, pre-fit medical evaluations are discussed in the Medical Findings section. The MPO underwent Respiratory Certification on September 27, 2001. He was noted to be physically able to use any respirator. Respiratory Certification documents covering some of his time as a volunteer preceding his hire (1997 and 1999) were included in the records we reviewed. Respiratory Certifications after hire included 2000–2006, 2008, and 2017–2021. The reason behind the 2009–2016 gap in documentation is unclear. The last Respiratory Certification before his death was conducted April 5, 2022, where he was cleared without restrictions.

Wellness/Fitness Programs

This FD has its own fitness center in their headquarters building. The policy stated that a Company Officer should "make a reasonable effort to allocate time for approved physical fitness activity" during the course of each shift as operations allow. Participation is voluntary. The policy further states the goals of the fitness program are to 1) meet physical job demands, 2) reduce the risk of injury or illness, and 3) enhance overall health and safety.

Investigation

The MPO was assigned as the pump operator of an Engine Company and was on duty during the Christmas holiday. Before this incident, he had responded to four alarms in the prior 24 hours.

On December 26, 2022, at 0112 hours, the MPO and his crew were dispatched to a structure [Photo 1], where people were reported inside. Weather conditions at the time of the call were historically reported to be 24° Fahrenheit with 55% humidity and 13 mile per hour wind speeds. Upon arrival, the MPO positioned his vehicle in the driveway near the B/C corner [Diagram 1 and Photo 2].

Diagram 1. Arial view of residential structure. Image provided by FD.

The MPO operated primarily outside, supporting interior crews and managing the fire engine in below-freezing conditions. The crew of the fire engine advanced a 1¾″ hoseline to the third floor through an interior stairwell on the B-side, stretching it to the D-side [Photos 3 and 4]. While supporting fireground operations, the MPO was observed pushing the hose into the building and assisting with hose advancement up to the second-floor landing because the firefighter at the nozzle was advancing the line solo up to the third floor. The officer at the time was conducting a 360 size-up. The second-floor landing was not considered to be an IDLH atmosphere (immediately dangerous to life or health). A high level of exertion was put forth by the MPO, assisting with heavy workloads.

The MPO collapsed while assisting with a self-contained breathing apparatus (SCBA) bottle change at the engine's pump panel. A "Mayday" was called immediately, and CPR was initiated on the scene. There was no Incident Safety Officer (ISO) assigned on the scene. Additionally, the Mayday call was not acknowledged by dispatch as required per FD protocol. An Incident Commander (IC) acknowledged the call, which put the proper chain of command into motion.

Photo 1. Multifamily residential structure A-B-side [Photo by NIOSH]

Photo 2. Multifamily residential structure C-side [Photo by NIOSH]

Photo 3. Multifamily residential structure D-side [Photo by NIOSH]

Photo 4. Multifamily residential structure D-side [Photo by NIOSH]

Emergency medical services (EMS) reported that they were informed that advanced cardiovascular life support (ACLS) was initiated at 0140 hours, approximately 1 minute after the MPO's witnessed collapse. CPR was initiated immediately. A supraglottic airway device was placed, and the MPO was ventilated with a bag valve mask. Bilateral tibial intraosseous lines were inserted in the field. While enroute, the MPO received four doses of epinephrine as the cardiac monitor showed asystole. He then displayed ventricular fibrillation and received two shocks at 300 joules each, during cycles of high-quality CPR.

ED records documented the MPO's arrival at 0215 hours, at which time he was intubated and a central line was placed in the right femoral vein. The cardiac monitor showed he varied between pulseless

electrical activity and asystole. ACLS measures were continued with additional doses of epinephrine along with sodium bicarbonate and calcium chloride. No pulses were detected at any time during the resuscitation. An arterial blood gas showed he was acidotic and hypercarbic; blood lactate levels were elevated at 14.7 millimole/liter (reference range: 0.5–2.2 millimole/liter) consistent with a prolonged cardiac arrest. There was no evidence of pericardial effusion or tamponade. At 0227, CPR was stopped for a pulse check; none was found. A cardiac ultrasound confirmed no activity, at which time the MPO was declared dead.

Table 1. Incident timeline

Time	Event	Personnel Assigned to Unit	Number of Personnel on Scene	Timelapse from Dispatch
Initial Dispatch				
01:12:39	Initial Dispatch of 3 Engines, 1 Rescue and 1 Truck	10 career	0	0:00
01:18:46	1st Engine Company arrives on scene	3 career	3	6:07
01:18:49	On-Call Chief arrives on scene	1 career	4	6:17
01:10:00	Working fire acknowledged- Quint requested from adjacent town	2 career		
01:19:24	1st Rescue Company arrives on scene	2	6	6:45
Additional Units				
01:20:33	2nd Alarm- 3 additional companies dispatched (not mutual aid) (2nd Truck, 4th and 5th Engine- all Volunteer)		6	7:54
01:21:08	2nd Engine Company arrives on scene	3 career	9	8:29
01:21:45	1st Truck Company arrives on scene	2 career	11	9:06
01:26:15	3rd Engine Company arrives on scene	3 volunteers	14	13:36

01:33:41	Mutual Aid Quint Company arrives on scene	2 career	16	21:02
01:39:14	Mayday called for firefighter down- elapsed time 26:35:00			26:35
01:40:53	4th Engine Company arrives on scene	3 volunteers	19	28:14
01:42:39	5th Engine Company arrives on scene	3 volunteers	22	30:00
01:43:30	Mutual Aid requested for 4 Engines, 1 Truck, 1 Rescue and Battalion Chief from adjacent town	26 career		30:51
01:52:43	2nd Truck Company reports mechanical issues while enroute- never arrives	2 volunteers	22	40:04

Medical Findings

Following his hire when no medical conditions were reported, the only medical assessments available to review on the MPO were:

- Respiratory Questionnaire Health Surveillance Record (RQHSR) forms from pre-fit test medical clearance evaluations conducted by the FD's Occupational Medicine contractor covering 2017–2022,
- Records from his primary care provider (PCP) covering June 15, 2020–May 13, 2021, and
- Records from his cardiologist covering March 4, 2021–March 25, 2022.

Here is a summary of pertinent medical findings in chronological order:

3/13/1996: Initial assessment when MPO first affiliated with the FD as a volunteer

No active medical issues, no medications; PFTs normal (Forced Vital Capacity (FVC)=5.0 L); weight=260 pounds (lbs.)

8/2/2000: Assessment upon hiring as paid crew member

Medically cleared; PFTs normal (FVC=5.0L); weight=250 lbs. (BMI=36.9 kg/m^2); blood pressure (BP) normal at 120/76 mm/Hg; normal exercise stress test (EST).

2017-2019: Annual RQHSRs

No noted medical concerns related to respirator use; FVC=3.7-3.8L; weight=310-337 lbs., BP=151-170/84-89 mm/Hg

5/13/2020: Annual RQHSR

Occupational medicine physician noted that “due to BMI 50 and age>40 in firefighter occupation that a stress test was needed to assess his capability to wear SCBA and assess coronary risk… at this time I could not complete the respiratory certificate”; weight=340 lbs.; BP=145/80 mm/Hg

6/15/2020: Initial visit with PCP. Stated reason for this visit: needed a referral to cardiology for a stress test.

PCP noted elevated blood pressure without prior diagnosis of hypertension and that he was overweight. The PCP sent out baseline labs including a metabolic panel, hemoglobin A1c, lipid panel and thyroid panel to assess possible reasons for his excess weight (diabetes, kidney failure, hypothyroidism, etc.). The PCP asked MPO to return in a week for a BP recheck and to start a low fat and low salt diet and walk daily for 45 minutes. MPO was subsequently diagnosed with high blood pressure, type 2 diabetes, and elevated lipids.

7/1/2020: Exercise stress test from cardiologist prior to new patient visit

MPO achieved 10.1 METS over 7 minutes. The test was ended due to fatigue. No chest pain or evidence of ischemia on the exercise EKG was reported. This EST was done without imaging. Although there was no arrythmia, the cardiologist noted isolated premature ventricular contractions (PVCs). This EST was reported as negative, and the MPO was cleared without restrictions.

3/4/2021: New patient visit to cardiology

Stated reason for visit: “cardiac evaluation due to having COVID-19 in October”. Current problem list included diabetes, essential hypertension, obesity, hypercholesterolemia, moderate aortic stenosis, obesity and history of COVID-19 disease. He was on multiple medications to manage the diabetes, hypertension, and elevated cholesterol.

3/11/2021: Transthoracic echocardiogram

Showed normal function of both ventricles, moderate left ventricular hypertrophy (LVH), and mild dilation of the left atrium. Moderate aortic stenosis (AS) with resting hypertension (high blood pressure) was noted.

5/13/2021: PCP visit

Weight=328 lbs.; BP=130/90 mm/Hg; HgbA1C=6.1%

3/25/2022: Cardiologist visit

Weight=330 lbs.; BP=134/88 mm/Hg

4/5/2022: Annual respiratory certification

Cleared without restrictions; weight=330 lbs.; BP=160/92 mm/Hg

Autopsy Findings

The autopsy was done on December 27, 2022. The cause of death was determined to be hypertensive and atherosclerotic cardiovascular disease (ASCVD) with contributing factors of obesity and bicuspid aortic valve (BAV). His weight was 342 lbs. and height was 70 inches, resulting in a BMI of 46.4 kg/ m^2.

Examination showed an enlargement of the heart, at 840 grams (g), and abnormal thickening of the left ventricle wall. Heart weights for males with a normal BMI (18.5–24.9 kg/ m^2) average 308 g while

those with a BMI ≥ 30 kg/m^2 may average 377 g, with a range 273–575 g [Molina and DiMaio 2012a]. No significant atherosclerosis (cholesterol plaques) was found in any of the coronary arteries and only a slight amount of plaque was found in the aorta.

Moderate dilation of all four heart chambers was noted, along with the presence of a BAV that showed moderate to marked calcifications of both flaps. There was no evidence of stroke (ischemic or hemorrhagic). The abdominal wall pannus (excess skin and fat that hang down from the abdomen) was approximately 2.5 inches thick. The liver was abnormally enlarged at 3,160 g with fatty changes, and the spleen was abnormally enlarged at 510 g. The mean weights for these organs in males with a BMI ≥ 30 kg/m^2 are 1,874 g for the liver and 172 g for the spleen [Molina and DiMaio 2012b].

Discussion

Medical clearance for respirator use

As described above, the only medical records available for the time period between 2000 and 2020 were RQHSR forms from pre-fit test medical clearance evaluations conducted by the FD's Occupational Medicine contractor. There was no evidence of other routine/preventive medical care during that time period.

Due to the potential physiologic strain wearing various types of respirators may place on the body, the OSHA Respiratory Standard 1910.134(e)(1) requires an employer to "provide a medical evaluation to determine the employee's ability to use a respirator, before the employee is fit tested or required to use the respirator in the workplace." The standard also requires that this medical evaluation includes gathering information included in the OSHA Respirator Medical Evaluation Questionnaire. Part A Section 2 of the OSHA standard includes a list of symptoms, diagnoses, and medications taken for specific conditions. A physician or other licensed healthcare professional (PLHCP) administers the questionnaire or reviews responses if self-reported. The PLHCP performs a physical examination and then determines if any follow-up testing is needed to make a determination regarding the employee being safe to use (and be fit tested for) the respirator required for the job. The Respiratory Questionnaire Health Surveillance Record (RQHSR) form appears to be this FD's version of the OSHA Respirator Medical Evaluation Questionnaire. Note that this medical examination focused on the question of the ability to safely wear the respirator for which certification is being sought and not a comprehensive medical assessment conducted as part of an annual medical examination as recommended by the NFPA. On the last page of the RQHSR, the healthcare provider must indicate if the firefighter is medically cleared for respiratory use or not and if any further action is needed.

Atherosclerotic Cardiovascular Disease (ASCVD) risk

Heart health assessment as per NFPA 1582: Starting at age 40 years of age, all firefighters should have an annual resting EKG. Additionally, annual cardiac risk assessment should be performed, using either the 2-year Framingham risk table or the 10-year risk calculator created jointly by the American College of Cardiology and the American Heart Association (ACC/AHA). Screening with either of these 2 methods should begin at age 40 for asymptomatic firefighters with no known history of ASCVD. If a firefighter has a 2-year 2-4% risk of ASCVD or a 10% to <20% risk of ASCVD over the next 10 years, the firefighter should undergo symptom-limiting exercise stress testing (EST) with imaging [e.g. echocardiography, technetium (99mTc) sestamibi study] to at least 12 METs*.

If EST with imaging is positive, the firefighter should be referred to a cardiologist for further evaluation. Consult NFPA 1582 2022 version Chapter 9, Table 9.7 to determine restrictions on essential job tasks. NFPA 1582 also recommends ASCVD risk assessment under other circumstances,

including for firefighters < 40 years old with a high risk of ASCVD, those with insulin-dependent diabetes, etc.

*Note that this is different from the routine EST used to assess firefighters' aerobic fitness. The MPO's 2022 visit with his PCP appears to have been prompted by the Occupational Medicine physician who conducted his RQHSR Medical Exam in May 2020. That physician stated that, due to his age and BMI, the MPO needed to have an EST done specifically to address his cardiac risk before they would complete that certification. It is likely this is the event that led him to obtain a PCP who could provide the referral to cardiology for the required EST. However, this EST was not conducted with imaging or up to 12 METS, so it was not an appropriate assessment of his ASCVD risk as per NFPA Standard 1582 [NFPA 2022].

Hypertension

The MPO's first visit with the PCP occurred on June 15, 2020. Although the MPO denied having any past medical history, it was immediately noted that his blood pressure was elevated at 160/90 mmHg. He was asked to return for a blood pressure recheck. When he returned, on June 25, 2020, his blood pressure had remained elevated at 142/90 mmHg. He was started on his first antihypertensive medication and advised to limit sodium intake.

Over the next two years, both the PCP and the cardiologist would place him on multiple medications to try to control his blood pressure. It is not uncommon that some individuals may require multiple medications that work via different pharmacological mechanisms to control hypertension. This can happen even when the patient is fully compliant with the prescribed medications and recommendations to limit sodium intake and exercise daily. An overview of medications commonly used to treat hypertension can be found at Managing High Blood Pressure | CDC.

Inadequate control or noncompliance with antihypertensive medications may result in changes such as those seen in the MPO's heart in the echocardiogram and as noted in the autopsy. These changes include an overall enlargement of the heart and thickening of the heart muscle that forms the left ventricle. The left ventricle is responsible for pumping blood out of the heart to the rest of the body, so that part of the heart muscle may enlarge if it has to overcome the resistance of a vascular system that is operating at a higher than normal pressure.

High Cholesterol/High Blood Lipid Levels

Atherosclerotic plaques can form from prolonged elevations of blood cholesterol and other lipid components like triglycerides and low-density lipoprotein (LDL). Although the MPO's coronary arteries and aorta were mostly free of these plaques, he did have slight atherosclerotic plaques in his aorta. The autopsy noted that he had "moderate to marked dystrophic calcifications of the cusps" of his BAV. Dystrophic calcification refers to loss of function due to the calcification process.

Although calcification due to lipid oxidation is often seen in mature cholesterol plaques on a heart valve and/or on the inside walls of blood vessels, calcification of even normal tricuspid aortic valves without cholesterol plaques seems to occur through a slightly different process. That process, which involves lipid infiltration and inflammation, can still result in significant reduction in the available cross-sectional area that accommodates blood flow [Otto 2002].

Calcification of the valve leaflets may have resulted in increasing the force needed for the MPO's left ventricle to push blood out across stiffened leaflets, which were not opening and closing normally. This compounded the work his heart had to do as it had to pump blood out into a system that was at above normal pressure due to his hypertension. This likely contributed to the enlargement of the heart muscle that forms the left ventricle [Carabello 2013].

Bicuspid Aortic Valve (BAV)

The autopsy revealed that the MPO had a congenital birth defect called bicuspid aortic valve (BAV). BAV occurs when a person is born with only two leaflets on the aortic valve or there are three leaflets but two fused together to some degree. The aortic valve controls blood flow between the heart's left ventricle and the aorta, as shown in Figure 1. It is estimated that BAV is the cause for over half the annual aortic valve replacements performed on adults over 50 years of age in the United States [Friedman et al. 2008].

Patients with BAV are at increased risk of AS because often two of the three leaflets are partially fused and/or there could be development of cholesterol plaques on the leaflets that have calcified. Both situations can limit the valve's ability to fully open, resulting in a narrowed space for blood to flow out of the valve. This is denoted as aortic stenosis (AS), which the MPO was reported to have on his March 11, 2021, echocardiogram, to a moderate degree.

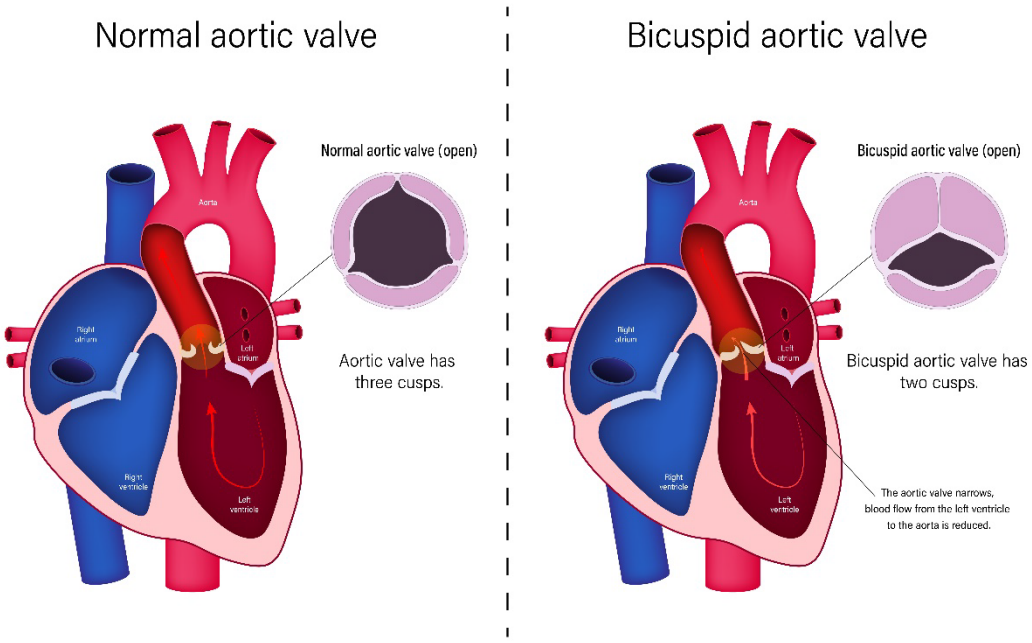

Figure 1: Blood Flow Restriction in a Bicuspid Aortic Valve vs. Normal Aortic Valve. Photo by ©Rujirat Boonyong/Getty Images Plus

People with BAV need to be closely monitored for early signs of backflow across the valve, called regurgitation. This can happen if the malformed leaflets don't close properly. Regurgitation can lead to heart failure and is an indication for aortic valve replacement. Management of high blood pressure is important in these patients. Hypertension can place more stress on an already malformed structure when the valve closes during the pumping cycle to allow freshly oxygenated blood to flow into the left ventricle from the left atrium.

BAV patients with high blood pressure are at an increased risk for aortic regurgitation if their blood pressure is not adequately controlled. BAV also places patients at increased risk for aortic aneurysm and acute aortic dissection. More information on BAV can be found Bicuspid Aortic Valve | Overview | Mayo Clinic. The MPO was not found to have aortic regurgitation on his 2011 echocardiogram.

Since the MPO consistently denied any past medical history as far back as his preemployment medical exam in 2000, he may not have been aware that he had this condition. Diagnosis of BAV is done via echocardiogram. It is often missed because it is difficult to get a clear view of the leaflets while they are constantly in motion during the heart pumping cycle. One study of 204 BAV patients in Texas showed that the number of aortic valve leaflets was frequently misidentified on echocardiogram, with 40% of patients receiving an inaccurate valve classification at least once. The degree of AS is easier to measure, as an echocardiogram can capture the increased velocity of blood flow across a narrowed, stenotic valve [Cramer and Prakash 2019].

Diabetes

Review of the MPO's medical records showed that at the time of his death, he was on multiple medications to control his high blood pressure, mixed hyperlipidemia (elevated levels of more than one component of the lipid panel, i.e., total cholesterol, LDL, and triglycerides) and diabetes.

Diabetes is diagnosed by having elevated values of at least one of three tests: fasting blood sugar, HgbA1c, or glucose levels 2 hours after a glucose challenge. Prediabetes refers to elevations of these tests that are above normal levels but don't quite reach the diagnostic threshold. These are outlined in Table 2.

Table 2. Three diagnostic criteria for diabetes

Criteria	Normal	Prediabetes	Diabetes
Fasting blood sugar	< 100 mg/dL	100–125 mg/dL	≥ 126 mg/dL
HgbA1c	< 5.6%	5.7%–6.4%	≥ 6.5%
Blood glucose levels 2 hours after glucose challenge	< 140 mg/dL	140–199 mg/dL	≥ 200 mg/dL

milligrams per deciliter = mg/dL Source: Table 2 from [Powers et al. 2022]

On his February 26, 2021, office visit with his PCP, the MPO's fasting glucose level was 155 mg/dL and his HgbA1c was 6.4%. The most recent HgbA1c was 6.5% on March 7, 2022.

The PCP recommended that the MPO start a low carbohydrate (as carbohydrates are converted by the body into glucose for use) and low fat diet, and increase his exercise to assist with weight management. When his HgbA1c remained elevated, at the follow-up visit on June 25, 2020, he was diagnosed with Type 2 (non-insulin dependent) diabetes without complications. He was provided a glucometer to keep track of his blood glucose at home. This PCP also did a full lipid panel on the MPO as part of his initial assessment. Some of those components were found to be elevated, so the MPO was placed on a medication to help lower cholesterol levels.

Diabetes itself is not an absolute contraindication for work as a firefighter as per NFPA. However, NFPA does recognize the diverse impact that diabetes can have on the body as Table 9.8, Section 3, provides guidance for those classified as Type 2 diabetics who do "not require insulin therapy and are able to control the condition with diet, exercise, or oral hypoglycemic agents" [NFPA 2022]. It also lists medical evaluations that need to occur periodically to ensure that the non-insulin dependent diabetic firefighter is under appropriate medical care to monitor for diabetes-related conditions that could impair their ability to safely perform the essential job tasks of a firefighter such as checking HgbA1c at least four times a year, and ensuring the firefighter who is taking oral hypoglycemic agents

"had no episodes of severe hypoglycemia (i.e., requiring the assistance of another) in the preceding year. For more information, please see NFPA 1582, table 9.2 [NFPA 2022].

The American Diabetes Association (ADA) issued a statement in 2008 stating that "People with diabetes should be individually considered for employment based on the requirements of the specific job. Factors to be weighed in this decision include the individual's medical condition, treatment regimen (medical nutrition therapy oral glucose-lowering agent, and/or insulin), and medical history, particularly in regard to the occurrence of incapacitating hypoglycemic episodes" [ADA 2008]. These precepts were affirmed in NFPA 1582.

Periodic cardiac evaluations for firefighters with diabetes recommended by NFPA include a cardiac evaluation "every 2–3 years as medically indicated", including an EST with imaging to at least 12 METs. Since his diabetes was diagnosed in 2020, it is possible that a periodic cardiological evaluation as indicated due to his diabetes may have provided updated risk identification and reduction guidance if it had been conducted prior to his death in 2022. [NFPA 2022].

Obesity

Body weight was an ongoing issue for the MPO. When he started his employment at this FD in 2000, he was 69" in height and 250 lbs. with a BMI of 35.9 kg/ m^2. At the time of his death, he was measured at 72" and 325 lbs. with a BMI of 46.1 kg/ m^2. In the last 3 years before his death, consequences of the excess weight were becoming evident with the onset of prediabetes evidenced by elevated HgbA1c. The MPO's PFTs, which were done as part of his respiratory clearance evaluations during 2017–2019, all contained the same notation, "Mild airway obstruction, low vital capacity perhaps due to restriction of lung volumes." This is a known consequence of obesity as the weight of the extra soft tissue in the chest and abdominal walls may make it difficult to fully inhale and can appear as a restricted lung volume on PFTs [Dixon and Peters 2018].

NFPA 1582 recognizes health risks associated with obesity. It also acknowledges that other methods aside from BMI may be used to assess obesity because individuals with high muscle mass may exceed BMI but still be in exceedingly good shape. Alternate methods for determining obesity, such as skin fold measurements, are included in Sections 8.1.1–8.1.2 [NFPA 2022]. The standard includes a table on how BMI is divided into four categories as shown below:

Table 3. Body mass index (i.e., the Quetelet index) for obesity

BMI (kg/m^2)	**Classifications**
20 – 24.9	Desirable range for men and women
25 – 29.9	Grade 1 obesity
30 – 40	Grade 2 obesity
Greater than 40	Grade 3 obesity (morbid obesity)

Source: [NFPA 2022]

Summary

Firefighters with high blood pressure, increased BMI, diabetes, and elevated cholesterol levels have an increased risk for adverse cardiac events. Although the MPO was never a smoker, he did have other ASCVD risk factors including high blood pressure, diabetes, high cholesterol, excess weight and family history. It is critical that these conditions are discovered as early as possible so treatment can be started sooner.

A required annual medical evaluation through their FD may be an effective way to ensure firefighters have regular comprehensive assessments of their health. This could allow for prompt identification of new medical conditions as they arise because not all firefighters are under the care of a PCP. The medical clearance exam for respirator fit testing is not a substitute for a comprehensive annual medical evaluation.

Firefighters should be referred to the appropriate specialist once new medical conditions are diagnosed. A cardiologist can work with their PCP to manage high blood pressure, high cholesterol levels, obesity, etc. An endocrinologist, which is a physician specializing in disorders of hormones and the glands, can assist with managing diabetes. Education about diet and nutrition in controlling blood sugar levels are important and may also help with weight management. Early intervention is vital because the sooner ASCVD risk factors are brought under control, the more likely the firefighter is to have a long career with improved quality of life.

We have the physical data on the MPO as part of his required preemployment medical evaluation when he was hired in 2000. But we do not have the Respiratory Questionnaire Health Surveillance Records for 2001–2016. Because those records contain the firefighter's vital signs, body weight, and PFTs, it is not possible for us to know the specifics of the timing of weight gain or onset of hypertension.

It was not until 2020, when one of the Occupational Medicine physicians reviewing the MPO's records refused to certify him for SCBA use that he had an EST due to his weight of 340 lbs. (measured 69" in height), a BMI of 50 kg/ m^2, and a blood pressure reading of 145/80 mmHg. As a result, the MPO had to obtain a referral from a PCP to get the EST done. It was this PCP who ordered the tests at the MPO's first visit and discovered his diabetes, hypertension, and high cholesterol. Treatment for all these conditions started at that time. It is likely that the onset of diabetes accompanied the weight gain and may have contributed to any difficulty he had when trying to lose the weight. However, the lack of medical documentation does not allow for more than conjecture.

Implementing a required FD annual medical evaluation may have led to an earlier recognition of the medical conditions the MPO developed during his tenure at the FD. Physicians conducting these exams should be familiar with the firefighter's essential job tasks. They should also know the NFPA guidelines for managing medical conditions firefighters may have so they can complete these tasks safely.

Resources on these subjects can be found at the following:

- American Diabetes Association | Newly Diagnosed With Diabetes
- American Diabetes Association | Diabetes Can Affect Your Heart
- American Diabetes Association | Nutrition and Diabetes
- American Heart Association | Diabetes This website has a link to a free interactive course titled "Let's Talk About Diabetes, Heart Disease & Stroke," to better understand how these conditions are related and approaches to managing them.
- Managing High Blood Pressure | High Blood Pressure | CDC

Recommendations

NIOSH offers the following recommendations to reduce the risk of ASCVD -related events among firefighters at this and other fire rescue agencies across the country.

Recommendation #1: Consider requiring annual medical evaluations. Although medical evaluations are not required by department policy, NFPA 1582 recommends annual medical evaluations of members [NFPA 2022].

Discussion: NIOSH recommends that fire departments phase in an annual fitness evaluation program that is consistent with NFPA 1582, Chapter 8: *Annual Occupational Fitness Evaluation of Members*. This will ensure personnel can meet state and job requirements, and applies Chapter 9: *Occupational Medical Evaluations*, which covers tailored guidance for *Coronary Artery Disease and Hypertension* (Section 9.7), *Type 2 Diabetes That Does Not Require Treatment with Insulin* (Section 9.8), etc. [NFPA 2022].

Many firefighters do not have their own PCP. Annual medical evaluations sponsored by their fire department could ensure they have routine medical evaluations by a licensed healthcare provider for early diagnoses of new medical conditions. This will allow for prompt treatment/management, increasing the chance of a long fire service career and better quality of life, while decreasing the risk of complications due to untreated medical issues [NFPA 2022].

Recommendation #2: Consider providing NFPA educational material to FD-contracted healthcare providers on Annual Respiratory Clearance Medical Evaluations. This will better inform these providers on clearance guidelines for specific medical conditions [NFPA 2022].

Discussion: Occupational Medicine physicians who conduct the Respiratory Certification Medical Clearances Evaluations should be familiar with the essential firefighter job tasks. This will help them better identify firefighters who need additional medical assessments. Before signing off on a firefighter's ability to safely use SCBA, these physicians should consider the specific environments the firefighter may experience during a fire response. It is possible that this increased awareness will help other firefighters with undiagnosed medical conditions toward earlier diagnoses and treatment of conditions that may place them at increased risk for ASCVD events.

Recommendation #3: Reinforce education among firefighters, including fire academy trainees, that developing new medical conditions after beginning a career in the fire service can happen and is accounted for in NFPA 1582. This standard is focused on ensuring that firefighters with various medical conditions can safely perform their essential job tasks while receiving the appropriate medical care for those conditions [NFPA 2022].

Discussion: Sometimes misperceptions or misunderstanding of standards may result in a firefighter being hesitant to report medical conditions or signs/symptoms if they are concerned that doing so may endanger their employment. We have no way of knowing if this played a role in the MPO's case but it is a possibility that can be addressed by education from the FD leadership.

Recommendation #4: Encourage all FD members to seek prompt medical care for new symptoms and medical concerns. Recommend that all members obtain a PCP regardless of any required FD annual medical evaluation. Having an existing relationship with a healthcare provider can enable discussion and management of new health issues as they arise.

Discussion: Having an established relationship with a PCP has many benefits. A PCP who knows a patient's past medical history and can coordinate care between any specialists provides a better quality of care. This is a better option than seeing a different provider at an ED or Urgent Care Clinic each time healthcare is needed. First responders often have difficulty taking time to care for themselves as well as they do for the public they serve. However, it is for that very reason they should ensure their best health to allow for a long career and good quality of life.

Recommendation #5: As required by OSHA's Respirator Standard, a Respiratory Clearance Medical Examination should precede each annual Respirator Certification (fit test). Consider creating a consolidated file management system to ensure this is occurring and provide easy access to past records.

Discussion: The records we obtained from this FD came from a variety of sources. This may have contributed to the gaps in documentation. Records should include an RQHSR for each Respiratory Certification/fit test for each year the firefighter is certified for SCBA and/or other respirator use. The RQHSR is a self-reported review of symptoms documenting the firefighter's current health issues. This is followed by a physical exam done by a physician who certifies if the firefighter is medically cleared for the intended respirator use. Each firefighter should have an RQHSR stating the firefighter is medically cleared for respirator use prior to each Respiratory Certification/fit test.

We were provided Respiratory Certifications for 1997, 1999–2002, 2004–2006, 2008, and 2017–2022, but we were given only the RQHSR forms for 2017–2020. An improved records management system could alleviate some of these issues and create a more efficient tracking system for the FD.

Recommendation #6: Assess emergency documentation procedures with consideration of consolidating EMS and FD call records.

Discussion: If possible, FD might consider exploring options to consolidate EMS and FD records. Merging these records may provide clarity of timelines and systems for future case studies and debriefs.

Recommendation #7: Review FD Mayday protocol with the dispatch office to ensure understanding and compliance to FD standard operating procedures.

In this incident, the FD had an established standard operating procedure for Mayday calls; however, the dispatcher did not recognize the Mayday call. Fortunately, an IC did hear the call, acknowledged it, and set into motion the proper chain of events to follow. Ideally, the FD would find out why dispatch did not acknowledge the Mayday call and rectify the situation by working with communications to safeguard future compliance. The FD may use the following standards to support their conversation with dispatch: *NFPA 1500 Standard on Fire Department Occupational Safety, Health, and Wellness;* and *NFPA 1561 Standard on Emergency Services Incident Management System and Command Safety.*

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program's Medical Team based in the Division of Field Studies and Engineering in Cincinnati, Ohio. This investigation was conducted and this report was coauthored by Judith Eisenberg, MD, MS; Rob Saunders; and Andrea Wilkinson, MS, ATC/LAT. Dr. Eisenberg is a board certified Emergency Medicine physician, Mr. Saunders is a former NIOSH Technical Information Specialist, and Ms. Wilkinson is a Health Scientist. Mr. Saunders retired after 31 years with the Pike Township Fire Department, Indianapolis, Indiana. In addition to having served as a firefighter, paramedic, heavy

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