High-intensity cardiac rehabilitation training of a firefighter after placement of an implantable cardioverter-defibrillator

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Firefighters who have received an implantable cardioverter-defibrillator (ICD) are asked to retire or are permanently placed on restricted duty because of concerns about their being incapacitated by an ICD shock during a fire emergency. We present the case of a 40-year-old firefighter who, after surviving sudden cardiac arrest and undergoing ICD implantation, sought to demonstrate his fitness for active duty by completing a high-intensity, occupation-specific cardiac rehabilitation training program. The report details the exercise training, ICD monitoring, and stress testing that he underwent. During the post-training treadmill stress test in firefighter turnout gear, the patient reached a functional capacity of 17 metabolic equivalents (METs), exceeding the 12-MET level required for his occupation. He had no ICD shock therapy or recurrent sustained arrhythmias during stress testing or at any time during his cardiac rehabilitation stay. By presenting this case, we hope to stimulate further discussion about firefighters who have an ICD, can meet the functional capacity requirements of their occupation, and want to return to work.

The National Fire Protection Agency (NFPA), which develops and promotes standards for firefighter health and safety, recommends that firefighters with an implantable cardioverter-defibrillator (ICD) retire or be permanently restricted from performing strenuous emergency duties (1). The cardiac rehabilitation (CR) program at Baylor Heart and Vascular Hospital in Dallas, Texas, was contacted by a firefighter from another state who, after ICD implantation, was put on restricted duty. Because he needed medical clearance to return to full active duty, he wanted to undergo the high-intensity, occupation-specific training (HIOST) that we have developed for firefighters seeking to return to work after a cardiac event (2).

CASE REPORT

A 40-year-old off-duty firefighter with no significant past medical history suddenly collapsed after playing a game of racquetball. Friends retrieved and applied the automatic external defibrillator, which, after analyzing his cardiac rhythm, delivered a shock. When paramedics arrived, portable monitoring revealed ventricular fibrillation that necessitated a second shock; this initially restored a narrow-complex rhythm without the need for further intervention. The patient was transported to the hospital, where cardiac catheterization showed normal coronary

arteries and an echocardiogram showed normal left ventricular systolic function without significant structural heart disease. He had no family history of heart disease or sudden cardiac death. He took no prescription medications, his physical examination was unremarkable, and his body mass index was 24 kg/m². Having survived an out-of-hospital cardiac arrest secondary to apparent idiopathic ventricular fibrillation, he underwent implantation of an ICD.

The patient attended six sessions of traditional CR in his hometown before transferring to the Baylor program in Dallas, where he consented to participate 3 days per week for a total of 18 HIOST sessions. The training goal was to determine whether he could perform simulated firefighting tasks and exceed the required functional capacity of 12 metabolic equivalents (METs) (1) without his ICD delivering shock therapy.

During all 18 exercise training sessions, the patient's ICD was evaluated before and after exercise. For the first 2 weeks, these device interrogations were done in person and consisted of a lead impedance test, an electrogram amplitude test or sensing test, and a capture threshold test. Thereafter, the ICD was interrogated using the manufacturer's program designed for at-home defibrillator monitoring. The system allowed the patient to download all pertinent device information for remote evaluation. Under the supervision of an electrophysiologist, a clinical specialist (employed by the ICD manufacturer) reviewed each transmission for proper functioning of the device and for the presence of arrhythmias.

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Figure 1. The patient performing (a) a stress test while wearing turnout gear and (b) a hose carry while wearing a weighted vest.

At the beginning and the end of the 18-session series, the patient completed a treadmill stress test while wearing firefighter turnout gear and a calibrated portable metabolic system (K4 b², Cosmed USA Inc., Chicago, IL) that captured his oxygen consumption data (*Figure 1a*). The maximal stress test protocol included 2-minute stages at speeds of 3.3 to 4.2 mph and changes in grade from 0% to 25%. The indications for terminating the test were those designated by the American College of Sports Medicine (3).

The HIOST sessions were 75 minutes long and comprised different combinations of exercises to ensure that the patient's training simulated the physical demands of firefighting. Nurses and exercise physiologists from the CR program provided exercise training, clinical testing, and monitoring during all sessions.

The HIOST workouts were customized by incrementally increasing not only the cardiovascular intensity but also the weight loads involved. While the patient trained, he wore a weighted vest that ranged from 10 to 55 pounds, the latter approximating the weight of his firefighter turnout gear. Some exercises, such as crawling under a barrier and using a stair-climbing machine, were for both muscular and cardiovascular endurance. Most of the simulated firefighting tasks involved carrying or using equipment, such as carrying a weighted box (range, 11.5 to 50 pounds), pulling a 30- or 60-pound fire hose, raising a pike pole weighing 5.5 to 15.4 pounds, hitting a tire for 20 to 60 seconds with a 9-pound sledgehammer, and climbing stairs while carrying a 15- or 30-pound hose (*Figure 1b*). Two exercises simulated victim rescue: 1) dragging a 50-, 95-, or 165-pound dummy along the ground, and 2) pulling a stair chair with a 50-pound dummy up two flights of stairs.

The high-intensity training was symptom limited, meaning that no heart rate or blood pressure limit was used to restrict exercise intensity. In conjunction with the device interrogation, the patient's blood pressure was measured before and after exercise. His electrocardiogram was continuously monitored

by telemetry, and peak heart rate and blood pressure measurements were recorded while he performed various training exercises. A physician was present in the rehabilitation room at all times.

During the HIOST sessions, the patient's blood pressure and heart rate remained within acceptable ranges (means, 153/52 to 189/78 mm Hg and 182 to 196 beats/min, respectively). His mean peak rate-pressure product value ($32,460 \pm 3864$) was consistent with the 36,000 threshold (4). One arrhythmia was noted: a single four-beat run of nonsustained ventricular tachycardia that was deemed clinically insignificant by the supervising cardiologist and the electrophysiologist who reviewed the case. The patient's ICD never delivered shock therapy, and he had no adverse events or symptoms that

required the discontinuation of any exercise session.

DISCUSSION

Firefighters with an ICD, such as the 40-year-old subject of this report, are asked to retire because they cannot fulfill NFPA essential job task 13: "Functioning as an integral component of a team, where sudden incapacitation of a member can result in mission failure or in risk of injury or death to civilians or other team members" (1). Concerns about sudden incapacitation are well founded, given that sudden cardiac death is the most common cause of on-duty fatalities among US firefighters (5, 6). A recent study of sudden cardiac death among firefighters aged ≤ 45 years identified the following risk factors: obesity, smoking history, left ventricular hypertrophy, coronary heart disease, and hypertension (7). The authors noted that obesity itself confers a twofold increased risk of sudden cardiac death, a finding that is especially worrisome in light of the high rates of obesity in the US fire service. Studies estimate that 30% to 40% of US firefighters are clinically obese; when the categories of overweight and obese are combined, the range is 73% to 88% (8). Our patient, who was forced to resign, was of normal weight and had none of the aforementioned risk factors for sudden cardiac death.

The US Department of Labor clearly outlines the job description of a firefighter (9). Many tasks are listed, some of which include strength activities defined as "very heavy work," such as lifting, carrying, pushing, pulling, and climbing. In a study of the metabolic demands of simulated firefighting tasks, firefighters who were more fit completed the tasks (e.g., carrying a high-rise fire hose pack up three flights of stairs, advancing a fire hose, and performing a rescue and mannequin drag) faster than those who were less fit (10). The patient in this case had no limiting symptoms and received no ICD shock therapy while he performed similar tasks. Furthermore, he reached a functional capacity of 17 METs during a stress test, exceeding the 12-MET minimum required for his occupation.

We acknowledge that the patient has a risk of future ICD shocks and that we did not simulate an active firefighting environment during his CR. The likelihood of future shocks cannot be predicted, and it is impractical in a CR setting to reproduce the smoke, heat, and emotional stress of an actual fire scene. What we can do is simulate firefighting tasks as closely as possible during training and examine other ways of evaluating firefighters who want to return to work (e.g., stress testing them in turnout gear). Our goal in this case was to provide as much information as possible so the physicians involved could make a well-reasoned decision about the patient's request for medical clearance.

To our knowledge, ours is the first report of a patient having an ICD placed for secondary prevention and then being able to exercise at a high functional capacity, with regular ICD interrogations showing no recurrent sustained arrhythmias. We present this case report to promote future discussion and clinical investigations about firefighters who undergo ICD implantation, are able to function at a high capacity, and want to return to active duty.

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