EDITORIAL

Firefighting and the Heart

Implications for Prevention

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Firefighting is widely recognized as a hazardous occupation. In particular, fire scenes are unpredictable and dangerous environments characterized by loud noise, high temperatures, flames, smoke with gaseous and particulate toxicants, and potential structural instability of affected buildings, among other hazards. Accordingly, during fire suppression, firefighters are at risk for various injuries, including burns, trauma, and smoke inhalation. Although less intuitive, the strenuous physical activity, emotional stress, and environmental pollutants encountered while fighting a fire place considerable strain on the cardiovascular system, and each of these exposures can act alone or in concert to increase the risk of cardiovascular disease (CVD) events among susceptible individuals.[1,2] The investigation of Hunter et al[3] in this issue of *Circulation* solidifies and expands a growing body of science elucidating the pathophysiologic mechanisms[1,2,4] through which fire-suppression activities markedly increase the risk of CVD events among firefighters: 10- to >100-fold greater risk compared with nonemergency fire department duties.[2,5]

CARDIOVASCULAR STRAIN OF FIRE-SUPPRESSION ACTIVITIES

We use the term “fire-suppression activities” broadly here to refer to firefighting with the use of hoses and application of water, as well as to refer to forcible entry, building ventilation, and search and rescue operations at a fire scene, while distinguishing this class of duty from additional jobs performed by firefighters, such as medical and other calls. Structural fire-suppression activities are usually preceded by an alarm response, which produces an adrenergic “fight-or-flight” reaction with prominent sympathetic arousal.[1,2,4] The increases in heart rate and blood pressure continue until scene arrival, where suppressing a fire requires significant aerobic effort (stair and ladder climbing), anaerobic power (forcible entry, search and rescue operations), and static exertion (heavy materials handling, cutting and chopping to ventilate the building, and advancing charged hoselines). The use of heavy (>25 kg), encapsulating personal protective equipment and the extreme heat of the fire add further to cardiometabolic demands and can also lead to hyperthermia and dehydration.[1,2,4] As confirmed by the present and previous studies, all of these factors can produce further increases in heart rate and blood pressure, which are accompanied by alterations in blood flow, vascular shear stress, and electrolytes; decreased plasma volume; increased blood viscosity; a procoagulatory state[3,4]; and, as documented in the present study, low-level myocardial injury and ischemia.[3] While Hunter et al[3] emphasize that this state promotes myocardial infarction, it is crucial to recognize that the same constellation of cardiovascular stressors is also arrhythmogenic (Figure). In fact, the autopsies of firefighters succumbing to on-duty

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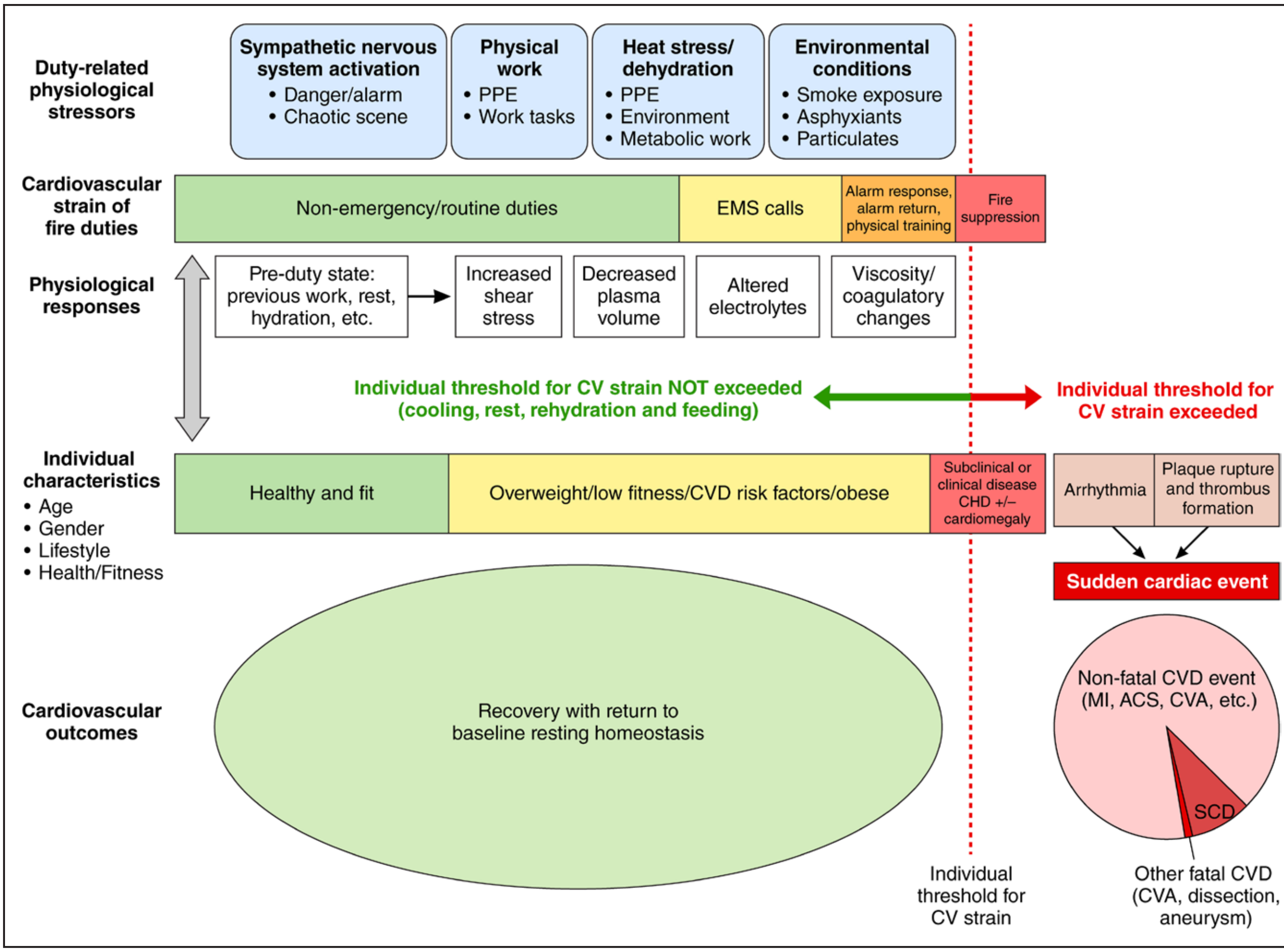

Figure. From left to right, both the average cardiovascular strain of fire duties and individual firefighter susceptibility increase.

In the vast majority of cases, even during fires where cardiovascular strain is quite high, firefighters with or without underlying health issues fully recover to their baseline states. Infrequently, however, the cardiovascular strain threshold of a vulnerable firefighter is exceeded, and through 1 or more of the mechanisms depicted, an acute CVD event is triggered. For every death caused by SCD, ≈17 to 25 nonfatal events occur. CV indicates cardiovascular; CVA, cerebrovascular accident; CVD, cardiovascular disease; EMS, emergency medical services; PPE, personal protective equipment; and SCD, sudden cardiac death.

sudden cardiac death (SCD) strongly suggest that most of these fatalities result from arrhythmias.[6,7]

CVD EPIDEMIOLOGY IN FIREFIGHTERS

One must look beyond fighting fires to fully understand why SCD is the leading cause of duty-related fatalities among US firefighters, causing ≈45% of all job-related deaths.[2,5] Although ≈33% of SCD events occur during fire suppression and the relative risk is highest during fires, >60% of firefighter SCD occurs across a variety of other duties. For example, CVD event risk is increased 5- to 7-fold during the sympathetic arousal of the alarm response.[1,2,5] Additionally, the odds of SCD are also increased during physical training activities (including simulated fires, but also simple exercise and other nonfire training drills). Further proof that heavy protective equipment, heat stress, dehydration, and air pollution are not required to trigger CVD events in public safety workers comes from law enforcement, where pursuits of and altercations with suspects increase the relative risk of SCD 30- to 70-fold compared with routine duties.[8] Moreover, despite the marked alterations in physiological function that firefighters experience during fire suppression, it is highly unusual to observe a CVD event in a healthy and fit firefighter.[2,4] The common denominator of occupational CVD events, including SCD across occupations and different types of duties, is an interaction between individual vulnerability and cardiovascular strain. When a public safety worker with underlying CVD (structural or coronary heart disease) is unable to tolerate a given load of cardiovascular stressors or threshold of cardiovascular strain, pathophysiologic changes precipitate or trigger a CVD event (Figure).

Consistent with the previous theoretical framework, case-control studies among firefighters demonstrate that SCD fatalities and CVD retirements have statistically higher burdens of classic CVD risk factors (eg, smoking, hypertension, and obesity) than healthy controls.[6,7,9] Furthermore, on-duty CVD events occur almost exclusively in firefighters with previously diagnosed CVD (20% to 30% of all events), firefighters with underlying (often subclinical) structural heart disease, firefighters with a clustering of traditional CVD risk factors and subclinical coronary heart disease, or persons belonging to >1of the 3 previous categories.[2,7,9] Autopsies of firefighter SCD victims typically show varying degrees of coronary atherosclerosis usually accompanied by left ventricular hypertrophy/cardiomegaly.[6,7] The major role of cardiac enlargement in fire service SCD is highlighted by numerous cases where coronary heart disease is not present or the degree of coronary occlusion is ≤40% to 50% and no evidence of coronary thrombus or plaque rupture is present. Compared with firefighters dying of traumatic causes, the hearts of firefighters dying of SCD are significantly heavier, and cardiomegaly (heart weight >450 g) conveys a 5-fold increase in the risk of SCD.[7] Older age also increases the risk of SCD and CVD retirement among public safety workers in a dose-response fashion, and this risk increases sharply beyond 60 years of age.[5,8,9] Depending on the duty performed, the risks of job-related SCD among firefighters ≥60 years of age range from ≈4- to 18-fold greater than that of colleagues 40 to 49 years of age.[5]

Clinical research is also informative. Obesity among firefighters is associated with lower aerobic fitness, the clustering of various CVD risk factors, and a higher risk of cardiac enlargement.[2,10,11] Firefighters with low physical fitness (≤10 METS) have a significantly and several-fold higher risk of metabolic syndrome, as well as EKG abnormalities and clinically abnormal heart rate recovery associated with maximal treadmill tests, compared with firefighters with excellent fitness (>14 METS).[12,13] In the study of Hunter et al, [3] 20 minutes of fire simulation training resulted in significant increases in cardiac troponin and more EKG-detected ischemia in carefully selected healthy firefighters. Repeating their experiments in firefighters who smokeand have health problems, low fitness, or even previously diagnosed heart disease would raise safety concerns. Yet it is known that many firefighters who respond on a regular basis to real fires and other stressful emergencies lack recommended fitness levels and have a high prevalence of CVD risk factors.[2]

IMPLICATIONS OF RESEARCH FOR REDUCING CVD IN THE FIRE SERVICE

Based on their study, Hunter et al[3] suggest measures to decrease the cardiovascular risks of fire simulation training, including limiting the duration of exposure, active cooling, and effective rehydration. Given the confirmation that fire-suppression duties result in prothrombotic changes, more widespread use of low-dose aspirin among middle-age firefighters should also be considered.[14] However, such approaches, although reasonable, would do little to reduce the overall burden of CVD in the fire service. Based on all of the established data from physiological, epidemiologic, and clinical studies of representative fire service populations as summarized earlier, we reiterate a series of appropriate preventive measures,[15] some of which are gradually being adopted by major US fire organizations. These measures include banning smoking and tobacco products in fire services, commonsense fitness and obesity standards, wellness programs that promote exercise and healthy diets, annual medical evaluations for all firefighters, and considering mandatory retirement from active firefighting (fire-suppression and other strenuous duties) at 60 years of age.

Hopefully, the impressive results of Hunter et al[3] will persuade clinicians that firefighting is uniquely stressful on the cardiovascular system and encourage practitioners to aggressively evaluate and treat CVD risk factors in these invaluable public servants and, when indicated, perform additional studies (such as exercise stress testing, coronary artery calcium scans, or echocardiography) to detect subclinical atherosclerosis or cardiac enlargement. Finally, given the markedly higher risk (≥15-fold after covariate adjustment) of SCD among firefighters with established coronary heart disease or other structural heart disease, clinicians should consider recommending that patients with such a profile refrain from participating in strenuous emergency duties such as fire suppression and fire simulation.[2]

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DISCLOSURES

Dr Kales reports serving as a paid expert witness, an independent medical examiner, or both in workers' compensation and disability cases, including cases involving firefighters. Dr Smith reports serving as a consultant in cases involving medical evaluations and firefighter fatalities.

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FOOTNOTES

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