Original Research

Deployment of Remote Advanced Electrocardiography for Improved Cardiovascular Risk Assessment in Career Firefighters

Brett A. Dolezal, PhD,[1] Marlon Abrazado, MS,[1] Maxim A. Batalin, PhD,[2] Denise Smith, PhD,[3] and Christopher B. Cooper, MD[1]

[1]*Exercise Physiology Research Laboratory, Departments of Medicine and Physiology, David Geffen School of Medicine, University of California, Los Angeles, Los Angeles, California.*
[2]*Wireless Health Institute, Henry Samueli School of Engineering and Applied Sciences, Los Angeles, California.*
[3]*First Responder Health and Safety Laboratory, Department of Health and Exercise Sciences, Skidmore College, Saratoga Springs, New York.*

Abstract

Introduction: *Firefighters perform strenuous muscular work while wearing heavy, encapsulating personal protective equipment in high temperature environments, under chaotic and emotionally stressful conditions. These factors can precipitate sudden cardiac events in firefighters with underlying cardiovascular disease. The purpose of this pilot study was to deploy and explore the feasibility of the resting "advanced" 12-lead electrocardiogram (A-ECG) as a remote firefighter risk assessment tool for improved assessment of cardiac risk.* ***Materials and Methods:*** *Conventional 12-lead resting electrocardiograms (ECGs) were collected for 5 min by using high-fidelity PC-based ECG hardware and software while subjects (*n = *21) rested comfortably. Raw data from the ECG system were securely transported via a secure network to a server where they were archived and processed. Authorized personnel performed both conventional ECG and A-ECG analyses from each digital recording, generating A-ECG "scores" in a blinded fashion. A separate cohort of firefighters (*n = *6) was trained to administer the A-ECG and rated the system's usability and frequency of technical problems.* ***Results:*** *Of the 21 uniformed personnel who completed testing, only 1 had a positive A-ECG score for coronary artery disease, which was subsequently confirmed by a cardiologist. All other subjects were classified as healthy by A-ECG. Firefighters trained to administer the A-ECG responded favorably in rating the usability of the system.* ***Conclusions:*** *We have demonstrated that a new technology, A-ECG, can be deployed for remote firefighter risk assessment being performed by firefighters themselves and interpreted centrally. This simple, time- and cost-effective approach can help identify individuals potentially at increased risk for line-of-duty death due to underlying cardiovascular disease.*

Key words: *cardiology/cardiovascular disease, electronic health, home health monitoring, sensor technology*

Introduction

Sudden cardiac death, the leading cause of line of duty death among firefighters in the United States, accounts for the largest proportion of fatalities annually.[1] Fire suppression activities are 10–100 times more likely to precipitate sudden cardiac events than routine station work.[2,3] In addition to these fatalities, approximately 800–1,000 firefighters suffer nonfatal heart attacks while on duty each year.[2,4] Firefighters perform strenuous muscular work while wearing heavy, cumbersome personal protective equipment (often weighing in excess of 25 kg) in thermally intense environments (100°C is considered routine), under chaotic and emotionally stressful conditions.[5,6] Despite these physically demanding job tasks, recent research indicates that many firefighters have suboptimal fitness levels and excess body weight,[7–9] thus creating an inherently perilous combination of low fitness and high stress that may precipitate an acute myocardial infarction, serious dysrhythmias, including sudden cardiac death, or cerebrovascular accidents in firefighters with underlying cardiovascular disease.[3,6,10–12]

Effective fire ground operations have a direct effect on public safety as the time required to successfully perform fire suppression and rescue activities has an unequivocal effect on civilian survivability and the extent of fire damage. Thus, detecting underlying heart disease through appropriate screening is particularly important in this occupational group—both because of the high rate of duty-related cardiovascular events and because of the public safety implications of being able to efficiently perform the required work of firefighting. Therefore any preventative measures, such as electrocardiogram (ECG) screening, that might predict cardiac events and enable interventions to forestall them might be life-saving. Conventional resting and exercise 12-lead ECGs are traditional examples of screening tools that are often used to detect cardiac abnormalities. The National Fire Protection Association Standard on Comprehensive Occupational Medical Program for Fire Departments[13] recommends a resting ECG as part of an firefighter's annual medical evaluation. Additionally, a stress test is recommended for individuals when clinically indicated by history or symptoms. However, it is known that resting ECGs, and even stress ECGs, often fail to detect underlying heart disease and are limited in their ability to detect structural abnormalities.

PHASER, the Physiological Health Assessment System for Emergency Responders, is a project charged with identifying, prioritizing, and reducing risk factors in emergency responders using new approaches and implementation of novel technologies. One of PHASER's goals is to provide evidence-based identification of risk as well as strategies to reduce risks that may lead to a cardiovascular event. Important among these strategies is the early identification of