# Sudden Cardiac Arrest and Death in United States Marathons

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## ABSTRACT

WEBNER, D., K. M. DUPREY, J. A. DREZNER, P. CRONHOLM, and W. O. ROBERTS. Sudden Cardiac Arrest and Death in United States Marathons. *Med. Sci. Sports Exerc.*, Vol. 44, No. 10, pp. 1843–1845, 2012. **Purpose**: There is no reporting system for marathon-associated sudden cardiac arrest (SCA) or sudden cardiac death in the United States. The purpose of this study was to estimate and characterize the risk of marathon-related SCA to assist with emergency planning. **Methods**: A retrospective Web-based survey was sent out to all US marathon medical directors ($n = 400$) to gather details of SCA including demographics, resuscitation efforts, mortality, and autopsy results, if available. **Results**: A total of 88 surveys (22%) were returned from marathons run from 1976 to 2009 for a total of 1,710,052 participants. Risks of SCA and sudden cardiac death were 1 in 57,002 and 1 in 171,005, respectively. Men made up the vast majority of SCA victims (93%, mean age = 49.7 yr, range = 19–82 yr). Arrest site distributions were 0–5, 6–14, 15–22, and 23–26.2 miles. CAD was reported as the cause of death at autopsy in 7 of the 10 fatalities. An automated external defibrillator (AED) was used in 20/30 cases and associated with a higher survival (17/20 survivors vs 3/10 deaths, $P = 0.0026$). **Conclusions**: SCA occurs in approximately 1 in 57,000 marathon runners, is more common in older males, and usually occurs in the last 4 miles of the racecourse. Prompt resuscitation including early use of an AED improves survival. Emergency planning to include trained medical staff and sufficient AEDs throughout the racecourse is recommended. **Key Words**: RUNNING, AED, MORTALITY, DEFIBRILLATOR

Since its inception at the first modern Olympic Games in 1896, the marathon has gained popularity with participation rising from an estimated 143,000 US marathon finishers in 1980 to a record high of 507,000 during 2010 (11,17). Because regular exercise promotes health (2), the concept of death during a marathon is unsettling. The vast majority of marathon deaths are caused by sudden cardiac arrest (SCA), defined as the sudden termination of cardiac activity with hemodynamic failure (3). Most victims of exercise-related SCA have no premonitory symptoms (18). Autopsy reports have shown that 65%–70% of all adult sudden cardiac deaths (SCDs) are attributable to CAD, 10% are due to other structural heart diseases (e.g., hypertrophic cardiomyopathy, congenital coronary anomalies), 5%–10% are due to primary cardiac conduction disorders such as prolonged QT and ion channel disorders, and the remainder are due to noncardiac etiologies (4–7,19).

The purpose of this study was to estimate and characterize the risk of SCA in marathon runners to assist with emergency planning at events.

## MATERIALS AND METHODS

A retrospective Web-based survey was sent to all US marathon medical directors ($n = 400$) in the autumn of 2009 by electronic and postal mail. A follow-up e-mail was sent in the spring of 2010. The 33-item survey addressed the number of marathon participants and associated SCA. Details of SCA and resuscitation efforts (including the use of an automated external defibrillator (AED)) were requested. If the athlete did not survive, the autopsy, cause of death, location of collapse, age, sex, medical history, and marathon history were recorded when available. The denominator of total participants was composed of only those marathon participants reported by directors responding to the survey. Ethical approval for this study was obtained from the institutional review board of Crozer-Chester Medical Center, and this study was exempt from the requirement of obtaining written informed consent.

## RESULTS

A total of 88 surveys (22%) were returned for marathons from 1976 to 2009 representing 1,710,052 runners in races that ranged in size from 30 to 30,000 participants. There were

30 SCAs reported including 10 deaths. The risk of SCA was 1 in 57,002, whereas SCD was 1 in 171,005. Of the 30 runners with SCA, 28 (93%) were male with a mean age of 49.7 yr (range = 19–82 yr). The event locations along the racecourses are shown in Figure 1.
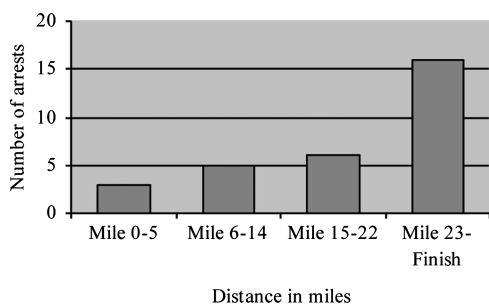
An AED was used in 17 of the 20 survivors and in 3 of the 10 deaths (Fig. 2). Survival was associated with AED use ($P = 0.0026$). The cause of SCA at autopsy was revealed to be CAD in seven cases and an anomalous coronary artery in one case. The cause of death was unknown in the ninth case, and no autopsy was performed in the 10th case.
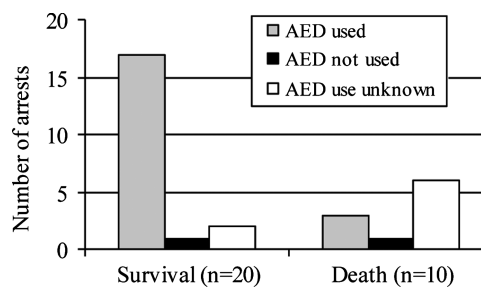
## DISCUSSION

Our study suggests that the risk of SCA in US marathons is approximately 1 in 57,000 with the majority occurring in middle- to late-age males. SCA is most common in the late stages of the race, and resuscitation is most successful when there are early responders and an AED is used. In most athletes who died, an etiology consistent with CAD was found at autopsy and consistent with past reports of SCA/SCD in this age population (4,13,14).

Whereas the overall risk for SCA is low, mortality after SCA, with no intervention, is greater than 95% (8,21). Ventricular fibrillation and ventricular tachycardia are the most common arrhythmias that lead to SCA. After initial collapse, survival decreases by 7%–10% with each minute that defibrillation is delayed (1). Prompt cardiopulmonary resuscitation has been shown to increase survival rate after SCA from 2.5% to greater than 8% (8). Defibrillation within 3 min of SCA can produce survival rates as high as 67%–74% (1,10). In addition, trials have shown that defibrillation less than or equal to 8 min after SCA significantly improved survival (20). Thus, early and effective cardiopulmonary resuscitation and defibrillation are vital in decreasing mortality after SCA.

Our data suggest that emergency planning with the use of an AED improves the chance of survival. A recent study by Roberts and Maron showed that the major determinant of survival from SCA in the marathon was the proximity of an AED to the collapsed runner (16). The authors noted that mortality after SCA decreased from 1 in 55,000 during 1976–1994 to 1 in 220,000 during 1995–2004 after improvements in emergency planning in the Twin Cities and Marine Corps marathons. Such improvements included fixed medical stations at 2- to 3-mile intervals and mobile first-aid teams on bicycles and golf carts equipped with an AED (15).

The SCA rate in our study contradicts the recently published data by the Race Associated Cardiac Arrest Registry (RACER) initiative, which estimated the incidence of US marathon SCA to be approximately 1 in 100,000 (9). Although both studies were retrospective in design, the major difference was in data acquisition. The RACER initiative used an Internet search of keywords from media reports from 2000 to 2010 for marathon SCA/SCD with the denominator for total participants obtained from Running USA, a trade organization and computerized cataloging system for all US marathons run from the corresponding dates. Our data were obtained from surveys completed by race medical directors. The denominator for total participants was obtained from the responses of those completing the survey. The authors of the RACER initiative noted that the study was limited because of the potential failure to capture all cardiac events. The strength of our study is that our data were obtained solely from race medical directors, with no media reports used, thus limiting the potential for underreporting of SCA/SCD.

Our study has several limitations. First, the retrospective design of the study may have led to recall biases. For example, a race medical director may be more likely to respond to the survey if survival after SCA occurred, leading to a potential positive event responder bias. Second, survey responses may have been limited because of incomplete data. Directors may not have had full access to patient information once an SCA victim was transferred to an outside facility. Third, there was a low response rate from marathon medical directors (22%). Thus, errors due to nonresponse may have existed. However, we believe that the sample size obtained (1.7 million participants) was sufficient to draw conclusions. Finally, because our data were obtained through a survey, the validity of our results was dependent on the honesty, motivation, and accurate record keeping of the responders. Because race medical directors are chosen for their expertise in the field as highly qualified medical professionals, we feel highly confident in the validity of the survey responses.

At this time, no national reporting system for marathon SCA/SCD exists. Notably, a review article on heart disease in

FIGURE 2—Outcome of SCA in marathons with respect to AED use in resuscitation.

FIGURE 1—Distance at which marathon SCA occurred throughout the marathon course.

marathon runners published in 1987 calls for a "more thorough reporting of all cases of sudden death in runners" to better understand the preventable aspects of SCD (12). Further prospective investigation is underway to more accurately assess the risk of SCA/SCD during marathon events.

In conclusion, these preliminary data strongly suggest that prompt resuscitation including the use of an AED provides a high survival rate for the victims of SCA during marathon events. Emergency planning with availability of AEDs throughout the racecourse is recommended. If resources are limited, focus should be placed on the last 4 miles where the majority of SCAs occur.

CLINICAL SCIENCES

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