

## CORRESPONDENCE

## Research Correspondence

## Evidence for Decreasing Occurrence of Sudden Cardiac Death Associated With the Marathon

**To the Editor:** The risk for sudden death caused by cardiovascular disease associated with the marathon has previously been reported as 1 in 50,000 finishers (1). In the last decade, road racing participation has increased more than 50% worldwide (2), and reports of fatal cardiac arrest during the marathon (and other road racing) continue to draw media attention and raise questions regarding the safety of this athletic activity. Therefore, we believe that it is timely to reassess the database of the Twin Cities and Marine Corps marathons through 2004 to determine whether the risk of sudden death associated with marathon racing has changed in the last decade, and specifically to establish whether the use of external defibrillators have had a positive impact.

The case records and registries of the 42-km Marine Corps Marathon (Washington, DC, 1976 to 2004) and the Twin Cities Marathon (Minneapolis-St. Paul, Minnesota, 1982 to 2004) spanning 29 years and a combined 52 races were reviewed. These public urban marathons are held each fall with similar weather conditions, attracting largely amateur racers who are not required to submit either entry qualifying times or evidence of preparticipation screening medical evaluations. Race records were analyzed to calculate the event rates for sudden cardiac death and non-fatal cardiac arrest and to compare the outcomes during the most recent 10-year period (1995 to 2004) with the original cohort from 1976 to 1994 (1). For those athletes who incurred cardiac events, a retrospective analysis of their medical and athletic histories was performed using available records and telephone interviews.

From 1976 to 2004, 441,924 runners successfully completed the marathons; the 1976 to 1994 and 1995 to 2004 subsets have virtually identical numbers of finishers, which permits comparisons (Table 1). Although marathon finishers from 1976 to 2004 were predominantly men, the proportion of women has increased from 18% during 1982 to 1994 to 37% for 1995 to 2004 (Table 1).

A total of five sudden cardiac deaths and four successfully resuscitated cardiac arrests (three with documented ventricular fibrillation and one initially with asystole), involving eight men and one woman (ages 19 to 58 years), occurred during or shortly after completing a marathon race (Table 2). Four of the five deaths occurred before 1995, and only one (in the year 2000) was during the most recent 10 years of this study.

The combined prevalence of sudden death and non-fatal cardiac arrest (i.e., overall event rate) decreased slightly from 1 in 44,000 race finishers for the 1976 to 1994 time period to 1 in 55,000 for 1995 to 2004, unadjusted for age and gender. However, the specific sudden cardiac death rates differed substantially for runners

before 1995 (1 per 55,000 finishers) compared with 1995 to 2004 (1 per 220,000 finishers) (Table 1).

The four cardiac arrest survivors had external defibrillation performed promptly within 5 min, including three in whom sinus rhythm was restored on site. Although cardiopulmonary resuscitation was attempted in all fatal and non-fatal cases, the precise timing of resuscitation relative to collapse was not known for the deaths that occurred in 1986, 1990, and 1993.

Seven of the nine runners with cardiac events, ages 32 to 58 years (all male), had underlying atherosclerotic coronary artery disease ( $\geq 50\%$  luminal narrowing) usually involving two or three main extramural arteries (Table 2). Of these, only case #9 had previously recognized disease, with coronary artery bypass grafting nine years before the fatal cardiac arrest. The other two cardiac events occurred in participants younger than 30 years of age without atherosclerotic coronary artery disease. A 19-year-old woman with anomalous origin of the left main coronary artery from the right (anterior) sinus of Valsalva died, and a 28-year-old man with cardiac arrest probably precipitated by a mitochondrial myopathy survived (3). Six of the nine runners with cardiac events had previously completed at least one other marathon.

The present analysis shows a sudden cardiac death rate of 1 in 220,000 marathon finishers during the last decade. This fatal event prevalence is less than the 1 death per 100,000 finishers reported in the combined New York City and London marathon races through the mid-1990s (4), is eight-fold lower than the estimated 1 in 15,000 to 18,000 for men during jogging and other vigorous exercise (5,6), and is four-fold less than our previously reported marathon sudden death rate before 1995 (1). Furthermore, the proportion of our runners with cardiac arrest who survived (four of nine, 45%; and three of four, 75% in the last decade) is much higher than the generally expected 5% survival with out-of-hospital cardiac arrests in urban communities of North America (7).

This decrease in mortality observed among race participants experiencing cardiac arrest since 1995 is largely attributable to the expanded access to external defibrillators now available on many road racing courses, including the marathon. Indeed, four runners survived their cardiac arrest primarily because of rapid defibrillation available within five minutes after collapse and rapid transfer to advanced life-support systems. Nevertheless, our survival data are not adjusted for demographic or other variables, and are not intended to represent precise estimates of changing risk.

The vast majority of medical encounters related to the marathon are relatively minor and self-limiting (8). Although

**Table 1.** Demographics and Clinical Events During Twin Cities and Marine Corps Marathon Races

	Total Finishers	Finishers Per Year	Male Finishers	Female Finishers	Nonfatal Cardiac Arrest	Percent	Per 100,000	Sudden Cardiac Deaths	Percent	Per 100,000
1976–1994	221,318	11,648	153,855 (82%)*	34,123 (18%)*	1	0.0005	0.5	4	0.0018	1.8
1995–2004	220,606	22,060	141,800 (63%)	78,806 (37%)	3	0.0014	1.4	1	0.0005	0.45
Total	441,924	15,239	295,655 (72%)*	112,929 (28%)*	4	0.0009	0.9	5	0.0011	1.1

\*Gender breakdown for 1976–1981 not available.

**Table 2.** Clinical Data for Cardiac Events Occurring in Nine Marathon Runners

Cardiac Event	Age/Gender	Year	Marathon	Cardiovascular Disease	No. Prior Marathons	Circumstances of Collapse
Nonfatal cardiac arrest						
1	46 M	1994	MC	CAD	—	Mile #8
2	54 M	1996	MC	CAD	1	Mile #21 (aid station)*
3	28 M	2000	TC	Mitochondrial myopathy	1	At finish line†
4	52 M	2003	TC	CAD	3	100 meters before finish
Sudden cardiac death						
5	32 M	1986	MC	CAD	3	Mile #15
6	40 M	1989	TC	CAD	0	15 min after completing race†
7	19 F	1990	MC	Anomalous LMCA	0	Mile #24
8	58 M	1993	MC	CAD	3	Mile #23
9	54 M	2000	MC	CAD‡	1	Mile #2

\*Evaluated for excessive fatigue; documented to have acute myocardial infarction. †Completed race in 4.5 h. ‡Previous coronary artery bypass grafting (three arteries).

CAD = atherosclerotic coronary artery disease; F = female; M = male; LMCA = left main coronary artery; MC = Marine Corps Marathon; TC = Twin Cities Marathon.

cardiac arrest is a rare occurrence, the clear implication of our data is that contemporary marathon race medical preparation with advanced life support (including rapid access to defibrillation) is life-saving. Successful defibrillations in both marathon events used manually operated defibrillators and rapid response teams that often included physicians, paramedics, and emergency medical technicians. Defibrillators and operators were placed in fixed medical aid stations at two- to three-mile intervals along the race route, at the finish line, and in mobile ambulances. Both marathons also currently deploy mobile first-response teams equipped with automatic external defibrillators moving along the race course with the runners on bicycles and in golf carts to facilitate access to defibrillation. In addition, race personnel are equipped with cell phones and short-wave radios for alerting the medical teams should a runner collapse. Indeed, it is our experience that the major determinant of survival from cardiac arrest during the marathon is the proximity of a defibrillator to a collapsed runner.

In conclusion, marathon road racing, although increasing in popularity and participation, is associated with a low (and decreasing) risk for sudden cardiac death largely because of the availability of advanced life support and timely defibrillation. That risk over the last 10 years is only 1 in 220,000 race participants. These observations offer an important measure of reassurance to potential marathon participants and underscore the power of rapid defibrillation after cardiac arrest for enhancing the safety of sports competition.

\*William O. Roberts, MD

\*Phalen Village Clinic  
1414 Maryland Avenue East  
St. Paul, Minnesota 55106  
E-mail: rober037@umn.edu

Barry J. Maron, MD, FACC

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## Letters to the Editor

### Cardiac Transplant Following Failed Fontan or Glenn Procedures

It is with great interest that we read the study by Jayakumar et al. (1) on the outcome following cardiac transplantation after a failed Fontan or Glenn procedure. Because adults and children were included in the study population, it is difficult to draw meaningful comparisons to posttransplant survival data. Nevertheless, in the more recent era of overall pediatric and adult cardiac transplantation (1994 to 1998). International Society for Heart and Lung Transplantation (ISHLT) Kaplan-Meier survival rates are reported at 80% and 82% at one year and 74% and 70% at five years' posttransplant, respectively (2,3). In this context, patient survival with cardiac transplantation after a failed Fontan procedure, reported by Jayakumar et al. as 63% at one year, and 57% at five years, is of concern (1). The investigators have reported five-year combined survival rates in both groups (post-Fontan and post-Glenn) in a later era (1996-2001) as 77%, but it would be useful to report the posttransplant survival in the failed Fontan patients separately in this later period as these patients seem to have a worse outcome than those transplanted after a Glenn procedure. The majority of deaths occurred within seven days after transplantation, and they were due to hemorrhage, multiorgan failure, sepsis, and right ventricular failure. The increased mortality