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## Public Locations of Cardiac Arrest Implications for Public Access Defibrillation

Linda Becker, MA; Mickey Eisenberg, MD, PhD; Carol Fahrenbruch, MSPH; Leonard Cobb, MD

**Background**—The purpose of this study was to describe the public locations of cardiac arrest and to estimate the annual incidence of cardiac arrest per site to determine optimal placement of automatic external defibrillators (AEDs). This was a retrospective cohort study.

**Methods and Results**—Locations of cardiac arrest were abstracted from data collected by emergency medical service programs in Seattle and King County, Washington, from January 1, 1990, through December 31, 1994. Types of commercial and civic establishments were tallied and grouped into 23 location categories consistent with Standard Industrial Codes, and the number of sites within each location category was determined. With the addition of “public outdoors” and “automobiles” as categories, there were 25 location categories. During the study period, 7185 arrests occurred, 1130 (16%) of which were in public locations. An annual incidence of cardiac arrest per site was calculated. Ten location categories with 172 sites were identified as having a higher incidence of cardiac arrest ( $\geq .03$  per year per site). Thirteen location categories had a lower incidence of arrest ( $\leq .01$  per year per site). There were  $\approx 71\,000$  sites within these categories.

**Conclusions**—Placement of 276 AEDs in the 172 higher-incidence sites would have provided treatment for 134 cardiac arrest patients in a 5-year period, 60% of whom were in ventricular fibrillation. We estimate between 8 and 32 lives could be saved in 5 years. To cover the remaining 347 arrests occurring in public in a 5-year period, defibrillators would have to be placed in 71 000 sites, not including outdoors and automobiles. Placement of AEDs in public locations can be guided by the site-specific incidence of arrest. (*Circulation*. 1998;97:2106-2109.)

**Key Words:** heart arrest ■ defibrillation ■ survival ■ resuscitation

Placement of AEDs to provide for public access defibrillation holds the promise of shortening time from collapse to shock for VF, thereby improving survival. Even a small decrease in time from collapse to shock is a major factor in the VF survival rate. Because it is not realistic to place an AED in every public location, identification of those places in which cardiac arrest most frequently occurs should guide the location of public access defibrillators to maximize their usefulness.

In Seattle and King County, Washington, the first emergency personnel to arrive at the scene of a cardiac arrest are usually EMTs in a vehicle equipped with a defibrillator. Paramedics are simultaneously dispatched and arrive several minutes later. Faster defibrillation might be achieved by placing defibrillators in the community and training lay persons in their use. The purpose of the present study was to determine the location and incidence of cardiac arrest in public places to plan for the most efficient placement of AEDs.

### Methods

We abstracted data from EMS registries of cardiac arrest in Seattle and King County, Washington (total population of 1.5

million in the 1990 census). Data were abstracted for the period January 1, 1990, through December 31, 1994, and included presumed cause, address, and location of arrest. A case was defined according to Utstein entry criteria.<sup>1</sup> In addition, the arrest had to have occurred in a public place before the arrival of EMS personnel, and resuscitation efforts had to have been undertaken by EMS personnel. All ages were included. Arrests due to trauma were excluded because defibrillation is not the first priority for most of these. A public place was defined as an indoor commercial or civic establishment or outdoors except immediately outside a patient's home. We excluded private residences, nursing homes, and fire stations. Also excluded were arrests in clinics or doctors' offices, on the grounds that an unknown number of them may have had defibrillators available. The majority of cases (89%) were due to presumed heart disease. The remainder (11%) included other causes such as respiratory problems, overdose, cancer, drowning, SIDS, neurological disorders, endocrine problems, and anaphylactic shock. Etiologic classification was based on field reports within the city and field reports, hospital records, and death certificates within the county.

The place of arrest was routinely recorded on the medical incident report. We classified the various places using SIC codes.<sup>2</sup> This is the classification standard that underlies all establishment-based federal economic statistics. There are unique SIC codes for every type of establishment, and the establishments are listed in approximately the same way they appear in the yellow pages of

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**Selected Abbreviations and Acronyms**

AED = automated external defibrillator  
 EMS = emergency medical services  
 EMT = emergency medical technician  
 SIC = Standard Industrial Classification  
 VF = ventricular fibrillation

the telephone directory. By grouping similar places, we compiled a list of 23 location categories. We added 2 categories, outdoors and automobiles, for a total of 25 location categories. We calculated an annual incidence of cardiac arrest for each location category; the number of arrests in each location category in 5 years was divided by 5 and then by the total number of sites in that category. Fire stations were excluded because they have defibrillators on site. We included 106 privately operated ambulances that did not have defibrillators on board. The denominator for vehicles was the  $\approx 1\,322\,000$  cars and trucks licensed in the city and county. For the location category "outdoors," there was, of course, no denominator.

**Results**

A total of 7185 nontraumatic cardiac arrests occurred before arrival of EMS personnel in Seattle and King County during the study period, and 1130 (16%) were in public places. Type of public place was missing for 96 cases. We determined there were  $\approx 71\,000$  public sites in the 23 location categories, not including cars and trucks or public outdoor locations. Location categories with the most sites were nonretail businesses (33 662) and retail stores (17 390). Of arrests in public, most locations were outdoors (32%; 385/1130) or in cars (15%; 168/1130).

There were 10 location categories that each had a relatively high annual incidence of cardiac arrest,  $\geq .03$  per site, or  $\geq 1$  arrest per 30 sites (1 arrest in 30 sites in 1 year is  $1/30 = .03$ ). These are listed in Table 1. It would require  $\geq 30$  sites in these types of location categories to yield 1 arrest per year. We termed these the higher-incidence sites. Of these, the Seattle-Tacoma International Airport had the

highest incidence, with 7 cardiac arrests per year. All these arrests took place in or near the terminal; none occurred in the air. The ferry/ferry terminal/train terminal category had an annual incidence of .1 per year. Stated differently, each ferry, ferry terminal, or train terminal had 1 cardiac arrest every 10 years, or a total of 10 ferries would have 1 passenger per year experience a cardiac arrest. These 10 location categories, numbers of arrests and sites, and annual incidence per site are summarized in Table 1.

The remaining categories had  $\leq 1$  arrest annually per 100 sites. These are termed the lower-incidence categories. The data are summarized in Table 2. For example, schools and churches had an incidence of .002 per year, or 1 arrest per year per 500 sites, and retail stores had an incidence of .0005 per year, or 1 in 2000 sites per year. The concept of higher-incidence sites and lower-incidence sites is reflected in a study from Dallas, Tex, that described the incidence of cardiac arrest as low in high-rise office buildings and high in the jail.<sup>3</sup>

The last 2 categories in Table 2 are arrests that occur in vehicles and outdoors. A very low incidence occurred in vehicles (1 arrest per year per 10 000 vehicles), although with 168 arrests, this category had the second-highest absolute number. The category "outdoors" had the highest absolute number of cardiac arrests. Obviously, there was no way to determine the number of sites in the outdoors category. We estimate that it would take 276 defibrillators to provide rapid defibrillation at the 172 sites with the higher incidence of cardiac arrest. The number of defibrillators needed per location category is shown in Table 1. Potentially, these defibrillators could be used to treat  $\approx 27$  cardiac arrests per year. An average of 10 AEDs would need to be placed in public settings to treat 1 cardiac arrest per year.

**Discussion**

Public access defibrillation has the potential to increase survival rates from cardiac arrest. As shown elsewhere,<sup>4</sup> survival is greater for individuals who experience cardiac

**TABLE 1. Incidence of Cardiac Arrest per Site: Higher-Incidence Location Categories**

Location Category	Arrests in 5 Years	Number of Sites	Annual Incidence Per Site, Average (Upper 95% CI)*	Number of Sites Required to Yield 1 Arrest per Year	Defibrillators Needed per Category
International airport	35	1	7 (12.5)	1	15
County jail	5	1	1 (2.4)	1	11
Large shopping mall	10	3	.6 (1.8)	2	27
Public sports venue	11	6	.4 (1.2)	3	24
Large industrial site	14	8	.4 (.8)	4	46
Golf course	23	47	.1 (.2)	5	47
Shelter	6	11	.1 (.3)	10	11
Ferries/train terminal	7	13	.1 (.3)	10	13
Health club/gym	18	47	.08 (.2)	12	47
Community/senior center	5	35	.03 (.07)	30	35
Total	134	172	N/A	78	276

\*All lower 95% CIs are 0.

**TABLE 2. Incidence of Cardiac Arrest per Site: Lower-Incidence Location Categories**

Location Category	Arrests in 5 Years	Number of Sites	Annual Incidence per Site, Average (Upper 95% CI)*	Number of Sites Required to Yield 1 Arrest per Year
Entertainment place	68	1245	.01 (.02)	100
Hotel/motel	22	377	.01 (.03)	100
Private ambulance	3	106	.03 (.07)	167
Bus	31	1138	.005 (.01)	200
Bar/tavern	11	413	.005 (.01)	200
Civic/fraternal	7	316	.004 (.01)	250
Government office	6	448	.003 (.005)	333
Nonretail business	48	33 662	.003 (.004)	333
Industrial manufacturing	40	3304	.002 (.004)	500
School/church	21	1943	.002 (.004)	500
Restaurant	36	4109	.002 (.004)	500
Retail store	47	17 390	.0005 (.001)	2000
Construction site	7	12 606	.0001 (.0003)	10 000
Vehicles	168	1 322 040	.0001 (.00003)	10 000
Outdoors	385	N/A	N/A	N/A
Total	900	N/A	N/A	N/A

\*All lower 95% CIs are 0.

arrest in public places. These individuals are younger, have fewer symptoms before arrest, are more likely to be in VF, and are more likely to have a witnessed arrest with bystander-initiated CPR. The survival rate of this group might be further enhanced by strategic placement of defibrillators in the community. Logically, the use of an AED located at or near the site of arrest would achieve defibrillation faster than if resuscitation efforts were delayed until the arrival of EMS personnel.

The distribution of defibrillators for the high-incidence categories could be accomplished in many different ways and would likely vary with each community. The following is a plan for placement of the 276 defibrillators in our 172 higher-incidence categories. At the international airport, there are 75 gates located in 15 clusters of 5 gates each. One defibrillator could be placed at each cluster. These 15 defibrillators would be used on 7 cardiac arrests per year. The county jail has 11 floors. Due to security restrictions regarding use of the elevators, efficient placement might consist of 1 defibrillator per floor. The 3 shopping malls have a total of 27 entrances to the outside; 1 defibrillator placed at each would provide coverage for 2 arrests per year. The 6 public sports arenas could have a total of 24 defibrillators, based on an average of 4 at each site, or 1 defibrillator per 15 000 spectators. They would be used in  $\approx 2$  arrests per year. The largest manufacturing company, whose plants account for 4 of the 14 sites in this category and  $>40\,000$  employees, already has 1 defibrillator per site. There are 23 EMT vehicles located throughout the plants. In the event of a medical emergency, an EMT is dispatched simultaneously with the fire truck that

carries the defibrillator and usually arrives before the company fire truck. If each EMT vehicle were equipped with a defibrillator, time to defibrillation could be shortened. These 4 sites would require a total of 23 defibrillators, which is  $\approx 1$  per 1500 employees. At this rate, all the industrial sites would have a total of 46 defibrillators. Each of the 47 golf courses, 11 homeless shelters, 18 health clubs, and 35 community/senior centers could have a defibrillator, as well as each of the 10 ferries and 3 ferry and train terminals.

Our study suggests that certain location categories would benefit from public placement of AEDs. Our data do not address the issues of cost-effectiveness, training requirements, maintenance of AEDs, or likelihood that the devices would actually be used when needed. A further limitation to the study lies in a certain amount of imprecision in determining the number of sites per location category. For example, in the retail business category, we were not able to discern how many were mail-order or in-home businesses. Also, the construction site category contains an unknown number of sites that were in operation for only part of the study period.

Only  $\approx 16\%$  of arrests occur in public. We did not consider other factors that influence outcome, such as witnessed arrest, bystander CPR, or rhythm on arrival (60% were in VF on arrival of EMS personnel in the present study). On the basis of 80 VF arrests in the highest-incidence sites (60% of 134 cases) with a survival rate between 10% and 40%, we estimate that between 8 and 32 lives might be saved over a 5-year period with distribution of the 276 defibrillators proposed in Table 1.

Planning for placement of AEDs in public should be guided by the site-specific incidence of arrest. If we placed 276 defibrillators in the 172 sites with the highest incidence, we would have the potential for public access defibrillation for 134 arrests in a 5-year period,  $\approx 80$  of which would have an initial rhythm of VF. However, to cover the remaining 347 arrests in public, defibrillators would have to be placed in  $>71\,000$  sites, not including automobiles or outdoors. We conclude that placing defibrillators in public locations is a reasonable strategy, but probably only in locations with relatively high incidences of arrest. We suggest that each community identify those sites with high incidences of cardiac arrest to plan for rational placement of AEDs.

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