Sudden cardiac death (SCD) remains a major public health problem. More than 250,000 deaths in the United States are attributed to SCD annually, and recent statistics demonstrate that in 1999, there were 341,780 cases of out-of-hospital cardiac arrest, accounting for 47% of all cardiac-related deaths. Despite improvements in emergency systems across the country and advances in the prevention and treatment of cardiovascular diseases, the proportion of SCDs has increased 12% over the past decade, making the development of better therapeutic approaches for out-of-hospital arrest of primary concern.

An early step in improving survival after sudden cardiac events was the development of the “chain of survival,” defined as early access, early cardiopulmonary resuscitation (CPR), early defibrillation, and early advanced care. Strong evidence supports this concept. Approximately 85% of victims of cardiac arrest demonstrate ventricular tachyarrhythmias immediately after collapse, and a survival rate up to 80% has been reported when CPR and defibrillation are administered within minutes of a witnessed cardiac arrest. Furthermore, the majority of survivors of this event are patients who demonstrate ventricular fibrillation on arrival of emergency personnel. Because of this, over the past 2 decades, community-based strategies focusing on early defibrillation have emerged, most recently by employing the automated external defibrillator (AED).

Early evidence that the AED could be incorporated into an emergency response system was demonstrated in Seattle. In a landmark trial, provision of AEDs to firefighters resulted in improved survival as compared with CPR alone until the arrival of a paramedic (30% versus 19%, P < 0.01). This improvement likely resulted from a decrease in the time to defibrillation of 5.1 ± 3.2 minutes. Other communities have demonstrated similar improvement by tailoring AED deployment in their emergency systems to their particular circumstances, but survival from sudden cardiac arrest remains low in some urban areas (2% in Chicago, for example).

Although reproduction of the Seattle experience has been difficult, most experts accept that early defibrillation with the AED is both advantageous and desirable. Ultimately, the goal of the American Heart Association, as stated in their Public Access Defibrillation initiative, is to deploy AEDs widely with the aim of lay public participation. Before full deployment of public access defibrillation becomes a reality, however, the safety and efficacy of the devices in diverse circumstances must be established.

AED Use in Niche Environments
AED efficacy is well documented in certain areas. For example, in casinos, where a significant population of individuals with cardiac risk comes under substantial stress, AED programs in which the security personnel are designated responders have been developed. Such programs can be highly successful, as described by Valenzuela and colleagues, with 53% overall survival from ventricular fibrillation to hospital discharge. This result occurred with an average response time (collapse to shock) of 4.4 minutes, as documented by security cameras. Even more impressive, the survival rate was 74% for those receiving shock in <3 minutes.

Another niche in which the AED has proved successful is the commercial aircraft industry, as reported by our group in 2000. In the American Airlines experience, in which flight attendants were first responders, the rate of survival to hospital discharge from ventricular fibrillation was 40%. In addition to demonstrating that survival in the air can far exceed that seen in many land-based environments, this series has provided further confidence in the safety of the AED for patients who do not require a shock. In one half of the cases described, the AED served as a monitor for passengers who had not lost consciousness, yet it never recommended nor delivered a shock. Moreover, in the report of the first 200 AED uses aboard American aircraft, the device showed 100% sensitivity and specificity in identifying ventricular fibrillation.

AED Use by Police
In the present issue of Circulation, a more widely applicable use of the AED is reported. Myerberg and colleagues describe the deployment of AEDs in an urban police department. Beginning in 1999, all police vehicles in Miami-Dade County, Florida, were equipped with AEDs, and police officers received a 4-hour training session. A dual-dispatch response system was developed, in which police and conven-

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tional emergency medical services (EMS) were simultaneously deployed to assist cardiac arrest victims. This system resulted in substantial benefit as compared with a historical control that employed only EMS response (observed during the 2 previous years). Response by police averaged about 1.5 minute faster than that of the EMS (6.16 versus 7.56 minutes), and the dual-response system reduced overall first-responder time to just 4.9 minutes (compared with 7.6 minutes from the historical control). This translated to a statistically significant improvement in the percentage of those who survived “shockable” ventricular arrhythmias (17.2% survival rate, compared with a 9% survival rate in the historical control). The improvement in survival from shockable rhythms did not result in an overall improvement in survival, however, because of a high frequency of nonshockable rhythms (61%) from which only 12 of 453 (2.6%) survived.

The report by Myerberg and his coauthors12 is important in that it demonstrates the clear benefit of AED deployment in police responders in a primarily urban area. Although the benefit of AED deployment may seem obvious, objective data to support such programs have been scant. In Amsterdam, police historically have been shown to arrive a median of 5 minutes before standard EMS, which indicates that providing these early responders with AEDs will lay the groundwork for improved survival.13 In the less urban area around Rochester, Minn, simultaneous deployment of police and EMS-based AEDs resulted in 40% survival to hospital discharge in patients with ventricular fibrillation, although no benefit of police-based AEDs over EMS response was demonstrated.14 The survival benefit of early defibrillation was confirmed, however.

Police-based AED use relies on the commitment of the police responders. In the report by Myerberg et al,21 police responded to cardiac arrest in 6.16 minutes, whereas they responded to nonarrest situations in just 4.15 minutes. This begs the question, “What caused the delay in cardiac arrest response?” The authors’ explanation (that multiple vehicles are deployed to certain crimes, or that geography of districts and local incidence of arrest vary) misses a major concern—namely, whether police responders may have been uncomfortable with this new responsibility, which thus translated to a delay in response. This concern is supported by the experience in suburban and rural Indiana, as reported by Groh and colleagues.15 That study demonstrated no benefit when AEDs were deployed to the police, a result likely due to the fact that police arrived before EMS in only 6.7% of cases. Perceptions by police of factors limiting response included lack of comfort or confidence in providing medical care (43.8%) and concern over personal liability (25.0%). When the police did arrive first, the data support the findings of Myerberg et al12: time to shock was shortened by an average of 4.9 minutes, and survival from shockable rhythms trended to improvement (15% versus 10% for EMS first responders; \( P = \text{NS} \)).

Further evidence of early difficulties in deploying a police AED program is provided by the report from suburban communities outside of Pittsburgh.16 As in the Miami experience, police deployment with AEDs occurred simultaneously with EMS. Although police response was good, with police being first on the scene 61% of the time, they applied the AED in only 69% of the cases in which they arrived first. Reasons provided in the article include expected rapid EMS arrival, delayed patient access, prolonged assessment, and failure to take the AED to the patient. Despite this difficulty, the call-to-shock time was reduced 26% compared with a historical control (11.8 to 8.7 minutes), and when the police used the AED to shock ventricular fibrillation, survival increased to 26% (versus 3% for EMS). Overall, survival from ventricular fibrillation was not increased significantly (6% to 14%).

Taking the Miami-Dade experience in context of these other studies, it is evident that there is benefit in survival from shockable cardiac arrest afforded by simultaneous deployment of AED-equipped police. This substantially increases the overall number of AEDs, and in most communities, police cars are usually already on the road at the time of an emergency call. Different communities have specific limitations (such as vertical access, traffic, etc), and because of this, individual system evaluation will be necessary to achieve optimal outcomes. A key factor, as described above, is that there must be a satisfactory commitment by the police force to the concept of and comfort with the process. With adequate police training, education, and acceptance of the AED, significant improvement in response time and overall survival should be expected.

Even with simultaneous deployment by police and EMS teams equipped with AEDs, there are limitations to the rapidity of AED delivery to the arrest victim. The large number of patients with nonshockable rhythms in the study by Myerberg et al12 suggests a substantial delay, and all links in the chain of survival must be improved to further decrease mortality from sudden cardiac arrest. For example, it would be of interest to know what proportion of patients received bystander CPR in Miami, an intervention that has shown a 2-fold increase in survival.13 Deficient areas must be identified to effectively educate the public and strengthen the chain of survival. To do that, a uniform format for system reporting, the Utstein template, has been advocated as a way to facilitate comparison among different communities.17

The Miami-Dade experience serves to demonstrate the limitations of an AED program that is dependent on a device being delivered to the site of a cardiac arrest. Time passes between a bystander’s discovery of a victim and activation of the emergency response system. Even with immediate recognition, there are further delays in delivering the life-saving shock. The 5-minute response time reported in the study by Myerburg et al must be added to the time for the 9-1-1 activation and dispatch, as well as an additional 1 to 1.5 minutes from the time the rescuer arrives to delivery of the first shock (as was seen, for example, in the casino experience).10 This translates to at least 7 minutes from collapse to shock: too long a time to achieve high levels of survival.

Where Do We Go From Here?

The timely arrival of an AED into the hands of a competent operator is the greatest delay in providing defibrillation to victims of SCD. As stated above, however, a high rate of
survival cannot be expected because of inherent delays in reaching the patient with an off-site AED. On the other hand, if public access defibrillation were fully developed, with widely available AEDs and operators, the time to shock would be substantially reduced and survival would be increased. Becker et al\(^\text{18}\) defined locations where AEDs would be of greatest use, such that 276 AEDs would cover 25% of the arrests in Seattle and King County. This deployment at sports arenas, malls, and other high-risk sites becomes the next step to increased survival (and is ongoing), but only with more widespread deployment will we serve the other 75% of arrests occurring in public locations. Such widespread AED deployment would lead to far greater numbers of AED arrests occurring in public locations. Widespread public-access defibrillation depends on more than just the provision of on-site AEDs; there must also be qualified and willing operators of the AED. Although the 4-hour American Heart Association courses may represent the “gold standard” in basic resuscitation and AED use, such a prolonged training experience is probably not necessary and may detract from more universal AED training. The modern AED can be operated by a naïve 6th grader, with cardioversion performed in a mock code after just 90 seconds (as compared with paramedics who took 67 seconds).\(^\text{19}\) We would advocate the development of abbreviated instruction (perhaps omitting CPR, or at least the complex artificial respiration instruction), such that training could easily be accomplished over a lunch break. Perhaps even televised public service announcements would suffice in giving bystanders a sufficient understanding that would allow the operator to follow the written and voice instruction provided with the modern AED.

An example of successful implementation of a public access defibrillation program is the Chicago HeartSave program.\(^\text{20}\) As part of this program, publicly accessible AEDs were deployed across Chicago’s O’Hare and Midway airports. The units were well marked and attached to a wall alarm, and their implementation was accompanied by an employee training program, as well as public education and awareness programs (including televised messages throughout the airport). In the initial report, there was a 64% overall survival rate, with more than half of the rescuers being airport travelers without formal AED training.

The concept of public access defibrillation is presently being tested in the Public Access Defibrillation (PAD) trial, where matched communities are randomized to receive AEDs and training or not (with both groups being trained in cardiac arrest awareness, early call to 9-1-1, and CPR). Although the investigators are to be commended for the effort and the results will be valuable, we believe that the need for AED availability is so great that communities that can afford an AED program should undertake such an initiative without delay.

Interventions to Complement AED Use

In addition, further changes are necessary to enhance the chain of survival. Few in our society are trained in CPR, and there is often reluctance to perform CPR because of concerns about infection transmission in mouth-to-mouth ventilations. Furthermore, the method is difficult to perform correctly and requires a 4-hour time commitment for instruction. Recent studies suggest that during the first minutes of CPR, ventilation may not be necessary\(^\text{21}\) and may even prove detrimental. On the other hand, Cobb et al\(^\text{22}\) demonstrated that 90 seconds of CPR before administration of a defibrillation shock markedly improved survival in victims who have been down for >4 minutes. Adoption of a simpler method for basic CPR and abbreviated classes would decrease public apprehension and would facilitate more widespread training in basic resuscitation.

Innovative interventions may also have promise. Therapy with hypothermia improves survival in comatose resuscitated victims.\(^\text{23}\) These and other innovations must be tested prospectively and in sufficient numbers of patients to allow rigorous review and adoption, if indicated. Investigation into such therapies depends on objective clinical investigation and development of situations that allow and encourage research in the treatment of cardiac arrest. Unfortunately, the environment for such clinical trials has been relatively obstructive in recent years, although there is some cause for encouragement with recent calls for research and support of such studies (including addressing the issue of waiver of informed consent).\(^\text{24}\)

The care of sudden cardiac arrest remains complex and incorporates scientific and social challenges. The Miami-Dade experience represents one important step in a long journey toward optimizing care for the victim of sudden cardiac arrest.

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