Cardiac Arrest Outside of a Hospital
How Can We Improve Results of Resuscitation?

Hein J.J. Wellens, MD; Anton P. Gorgels, MD; Hans de Munter, MD

In the western world, one-fifth of all deaths occur suddenly and unexpectedly, ventricular fibrillation being a frequent mechanism. It happens approximately 300,000 times per year both in the United States and in Europe. This problem continues to haunt us, for we know that restoring normal heart rhythm by a defibrillation shock not only saves the life of the victim, but is often followed by many years of satisfactory living.

Can We Recognize the Victim Before the Event?

Much effort has been put into recognizing the person at high risk of dying suddenly and is clearer in the case of a previous life-threatening arrhythmia or successful resuscitation from circulatory arrest. In such patients, death from a new arrhythmic episode can be prevented by implanting a defibrillator. Accurate risk stratification is much more difficult in the large group of patients with known heart disease but without a history of a life-threatening arrhythmia.

Patients characterized by a previous myocardial infarction and poor left ventricular function, with or without non-sustained ventricular arrhythmias, can profit from a defibrillator implant, as shown by studies such as the Multicenter Automatic Defibrillator Implantation Trial-I (MADIT I), the Multicenter Unstable Tachycardia Trial (MUSTT), and MADIT II. However, only 10% of sudden cardiac arrest victims have such a high-risk profile.

The Challenge

The challenge is therefore to improve the outcome of resuscitation in the 90% of patients that we cannot recognize as being at high risk before the event. Of course, risk in the known cardiac patient should be minimized by improving myocardial perfusion and pump function by medical and surgical interventions and other secondary prevention measures. In half of the victims, however, cardiac arrest is the first manifestation of heart disease. That 90% has much less cardiac damage than the 10% with a high risk profile, and they should have a much better life expectancy when successfully resuscitated than the high risk category.

This has been the basis for continuing efforts (unfortunately without much success) to educate the public on seeking immediate help when symptoms suggestive of acute myocardial ischemia occur, and also on performing correctly and rapidly the different steps required for survival in case of cardiac arrest. However, it still remains exceptional to save more than 5% of cardiac arrest victims. That figure has not changed during a 20-year period.

Public Access Defibrillation

Although the (semi)automatic external defibrillator (AED) has been available for a long time, only recently has a change in policy and removal made wide application of this device by the layman possible. Placing the AED in public settings and training laymen in their correct use gave new hope and resulted in improved outcome of cardiac resuscitation. The key to a successful treatment of circulatory arrest is defibrillation within the short time interval of a few minutes. This means that the AED has to be at the site of the victim within that time. This is a problem when we realize that 80% of cases of circulatory arrest occur at home. Currently ongoing studies are examining the benefit of having a dense network of AEDs in the community, with public access to these devices.

The Home AED

The knowledge that most victims of circulatory arrest have the event at home has been the reason to start studies placing the AED in the home of the patient at risk of dying suddenly. Extensive use of the device at that site has been envisioned.

However, the home AED has its limitations. Having the device at home means that a person other than the victim must be available, able to diagnose circulatory arrest, and be willing to use the defibrillator. Unfortunately, 40% of circulatory arrests are unwitnessed, making it usually impossible to restore normal cardiac rhythm within the 6 to 8 golden minutes after the start of arrest.

Shockable Versus Non-Shockable Rhythms

Defibrillation is a life-saving therapy in case of ventricular fibrillation (VF). However, sudden cardiac arrest may also be the consequence of asystole or pulseless electrical activity. Recent studies from both sides of the Atlantic suggest a decreasing incidence of VF as cause of cardiac arrest. Are victims being seen later after the onset of cardiac arrest or is VF becoming less common in patients with known heart disease who are adequately treated medically and surgically, including with β-blockade? Insight into these changes is
important because it necessitates a rhythm-based approach to cardiac arrest.

### The Weak Links in the Chain of Survival and How to Correct Them

Although after cardiac arrest, time to successful resuscitation can be prolonged by CPR, ideally the time interval between collapse by VF and defibrillation should not exceed 5 to 6 minutes. Several conditions should be fulfilled to reach that goal (Table 1). The first step is to make the time interval between collapse and call for help as short as possible. This requires a bystander who quickly overcomes the paralysis that occurs when one witnesses cardiac arrest. Currently, even with a bystander trained in CPR, it easily takes 1 minute to confirm circulatory arrest. That is the time required to call emergency medical services. It takes on average 2½ minutes after the call comes in for trained responders to be sent to the scene.

The dispatch time can be shortened by having a special telephone number other than 911 in the United States and 112 in Europe that is exclusively used for a cardiac emergency. Time between collapse and defibrillation can also be shortened by having a sufficient number of AEDs and a dense network of “cardiac arrest watchers” in the community. These are people living in the neighborhood who can be alarmed when cardiac arrest occurs.

### What Else Is Needed?

A major breakthrough in improving results of cardiac resuscitation could come from developing an apparatus specifically geared toward minimizing the time between collapse and the resuscitation effort, one that requires continuous registration of vital signs, such as cardiac rhythm or arterial pulsations with prompt recognition of circulatory arrest. This will reduce the time to come to the correct diagnosis by giving an audible alarm to attract bystanders in the home and in situations where there are no witnesses. The location of the victim should be transmitted to the nearest site of an AED in the community and to the emergency medical services, resulting in a marked reduction in time required for diagnosis and dispatch.

The device should also have a clock that allows for precise identification of the time of collapse and subsequent intervention, providing information that is essential for decision making in the individual victim. This point was recently stressed by Weisfeldt and Becker in their 3-phase time-sensitive model, which indicated that optimal treatment of cardiac arrest might be phase-specific. In the electrical phase, which lasts approximately 4 minutes, early defibrillation is required. In the next phase, the circulatory phase (4 to 10 minutes after cardiac arrest), oxygen delivery should precede attempts to restore normal rhythm by defibrillation. In the last phase, the metabolic phase (starting approximately 10 minutes after cardiac arrest), Weisfeldt and Becker suggested investigating the value of interventions such as controlled reperfusion after treatment with apoptosis inhibitors and external cooling.

Wearing the device will also indicate that the person wants to be resuscitated, a question one cannot answer in case of an anonymous victim. A reliable device, one able to continuously register artifact-free vital signs, probably requires intracutaneous or subcutaneous sensors. Vital signs should be transmitted to a wearable receiver able to analyze them and sound an alarm in case of circulatory arrest and to transmit the location of the victim. Recently, the PULSE initiative was published, in which a detailed description was given of scientific priorities and strategic planning for resuscitation research and life-saving therapies. However, little attention was given to the importance of developing a wearable, reliable device as described above. The development of such a device, some necessary features of which are shown in Table 2.

### Table 1. Weak Links in the Chain of Survival

<table>
<thead>
<tr>
<th>Weak Link</th>
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<tbody>
<tr>
<td>No witness</td>
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<tr>
<td>The time interval from collapse to start resuscitation</td>
</tr>
<tr>
<td>Absence of a trained bystander</td>
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<tr>
<td>Dispatch time</td>
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<tr>
<td>First responder and ALS not rapidly available</td>
</tr>
<tr>
<td>Absence of information about the exact time of collapse and of the</td>
</tr>
<tr>
<td>subsequent steps during the resuscitation effort</td>
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### Table 2. Technical Challenges in the Development of a Cardiac Arrest Device

<table>
<thead>
<tr>
<th>Challenge</th>
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<tbody>
<tr>
<td>Continuous monitoring of cardiac activity</td>
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<tr>
<td>Selection of the best sensors (ECG? Pulsations?)</td>
</tr>
<tr>
<td>Artifact-free recording</td>
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<tr>
<td>Wireless transmission of signals</td>
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<td>Reliable circulatory arrest detection</td>
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<tr>
<td>Miniaturization</td>
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<td>Low power consumption</td>
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<tr>
<td>Audible alarm</td>
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<tr>
<td>Location of the victim</td>
</tr>
<tr>
<td>Clock registering exact time intervals between arrest to start of</td>
</tr>
<tr>
<td>resuscitation and defibrillation</td>
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</tbody>
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### Diagram: Resuscitation for Sudden Cardiac Arrest

**Current approach**
- Cardiac Arrest
  - 1 min witness
  - 1 min dispatch
  - 2 min first responder
  - 2 min - AED in community
  - 3-5 min at the victim

**Device recognizing SCA and transmitting location of the victim**
- Cardiac Arrest
  - 1 min
  - 20 sec.
  - 1 min
  - first responder
  - AED in community
  - Advanced Life Support
  - 3-5 min at the victim
  - 4-6 min at the victim

**Time intervals**
- Current approach: 7-10 minutes
- Device: 4-7 minutes

SCA indicates sudden cardiac arrest.
Table 2, will be a real challenge. But, as shown in the Figure, it may give us a new opportunity to speed up the chain of survival, resulting in a reduction of sudden deaths outside the hospital. It might also allow us to apply more phase-specific therapies according to time elapsed after cardiac arrest. If we could bring the overall success rate of a resuscitation attempt after a cardiac arrest from 5% to 25%, an additional 70 000 lives will be saved yearly, both in the United States and in Europe.

Conclusion

Increasing public awareness of the frequency of sudden cardiac arrest and rapid access to an AED is likely to lead to a higher success rate of resuscitation attempts. However, a real breakthrough requires the development of a device that recognizes cardiac arrest, sounds an alarm, and transmits the location of the victim, shortening the time interval of the different steps in the chain of survival.

References


Key Words: Editorials ■ resuscitation ■ death, sudden ■ defibrillation.
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