Cardiac Resuscitation in the Community
Importance of Rapid Provision and Implications for Program Planning
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Several time-related variables involving resuscitation from out-of-hospital cardiac arrest were studied. Short time intervals from collapse to initiation of cardiopulmonary resuscitation (CPR) and to provision of definitive care were significantly associated with survival from cardiac arrest. The two times were jointly related, and one short time without the other was unlikely to result in survival. If CPR was initiated within four minutes and if definitive care was provided within eight minutes, 43% of patients survived. If either time was exceeded, the chances of survival fell dramatically. The time to initiation of CPR and definitive care are factors directly influenced by emergency medical service program decisions. A realistic option to improve time to initiation of CPR is widespread citizen CPR training. A possible option to improve the time to definitive care is the training of emergency medical technicians in defibrillation.

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AS a medical emergency, there is probably nothing more dramatic than sudden cardiac arrest. In recent years numerous mobile cardiac care programs have been established to reach cardiac arrest victims in the community and to provide definitive lifesaving care. To various degrees these programs have been successful, reporting up to 44% initial successful resuscitation and 23% eventual discharge for cardiac arrest due to ventricular fibrillation. The sooner resuscitation can be initiated following cardiac arrest, the more likely the patient is to survive. Yet, such an obvious truth only partially characterizes the relationship between time and successful resuscitation. There are, in fact, several time-related components that may be associated with survival from cardiac arrest. We define which time-related components are most predictive of survival from sudden cardiac arrest and discuss realistic program options to achieve these optimum times.

METHODS

Since April 1976 an evaluation study of paramedic programs has been conducted in King County, Washington. The study area (population 598,000) comprises the suburban area surrounding Seattle. The overall study, described in detail elsewhere, established a surveillance system to identify every case of out-of-hospital cardiac arrest receiving emergency care that occurred in the study area. A cardiac arrest case was defined as a person with a pulseless condition confirmed by an emergency medical technician (EMT) or paramedic. The cause and outcome (death, admission, or discharge) of each cardiac arrest were rounded to the closest half minute. In 17 witnessed incidents, this time could not be estimated. Time to definitive care was the sum of access time and paramedic response time. In 20 incidents this time could not be estimated. All times were rounded to the closest half minute. When the bystander stated that the fire department was called immediately, an access time of one minute was arbitrarily designated as one half minute. If collapse occurred after the arrival of the fire department, access time was zero, and time to initiation of CPR was arbitrarily designated as one half minute. If collapse occurred after the arrival of paramedics, time to definitive care was arbitrarily designated as one half minute.

Information about time-related components associated with the resuscitation was collected. These components, used as independent variables, were (1) access time, the time from collapse to the summoning of emergency aid; (2) response time, the time from the emergency agency receiving the call to the arrival at the scene by the first emergency vehicle; (3) time to initiation of cardiopulmonary resuscitation (CPR), the time from collapse to initiation of CPR; and (4) time to definitive care, the time from collapse to provision of defibrillation, intubation, or emergency medication (definitive care was provided either by paramedic units or hospital emergency room personnel in the cases for which paramedic services were not available). Only incidents in which the collapse was directly witnessed or heard were included: 569 (61%) of the 927 cardiac arrests. Unwitnessed cardiac arrests were not included because of the imprecision of defining time of collapse. Access time was determined at the scene by an EMT or paramedic questioning the bystander. Usually this was determined on arrival and before knowledge of the outcome. In 20% of instances, the bystander was also contacted by the research staff to reconstruct the events and clarify the time. Access time could not be determined for 17 witnessed cardiac arrests. Response times were taken from fire department dispatch logs. Response times were not available for 14 incidents.

Time to initiation of CPR, in the event of bystander-initiated CPR, was determined at the scene; in the event that the fire department initiated CPR, this time was the addition of access and response time. In 17 witnessed incidents, this time could not be estimated. Time to definitive care was the sum of access time and paramedic response time. In 20 incidents this time could not be estimated. All times were rounded to the closest half minute. When the bystander stated that the fire department was called immediately, an access time of one minute was arbitrarily designated as one half minute. If collapse occurred after the arrival of the fire department, access time was zero, and time to initiation of CPR was arbitrarily designated as one half minute. If collapse occurred after the arrival of paramedics, time to definitive care was arbitrarily designated as one half minute.

Information about other variables associated with the resuscitation, such as age, sex, type of emergency service (EMT vs paramedic), or cardiac rhythm, was collected, and the results are reported elsewhere. All patients were taken to fully staffed emergency rooms, and all admitted patients were monitored in four coronary care units. The paramedics in the area operate under identical standing orders, thus ensuring comparable medications and procedures.
**RESULTS**

From April 1976 to September 1978, nine hundred twenty-seven people in the study area had cardiac arrests owing to primary heart disease and received CPR by an emergency agency. A majority (569, 61%) of the incidents were witnessed by or the collapse heard directly by a bystander. Of the 569 patients with witnessed cardiac arrests, 123 (22%) were discharged compared with 9 of 358 (4%) unwitnessed cardiac arrest incidents (P<.001).

The average access time was 1.2 minutes (SD, 1.3). The average response time was 3.3 minutes (SD, 2.5). The average time from collapse to initiation of CPR was 3.2 minutes (SD, 3.0). The average time from collapse to definitive care was 13.1 minutes (SD, 11.4). The length of the average time from collapse to definitive care is partially accounted for by the 177 cardiac arrests for which paramedic services were not available. In these instances definitive care was provided later either by the second arriving paramedic unit or after the arrival at the hospital in those areas without paramedic services. The only exceptions were in the 37 instances when cardiac arrest occurred after arrival of the paramedics and the patient received almost instantaneous definitive care (eg, defibrillation). Of these 37 patients, 16 (43%) were eventually discharged.

Each of the four time components was significantly associated with discharge (Fig 1). For time to initiation of CPR, survival was fairly constant up to four minutes. If CPR was initiated within four minutes, 44 of 352 patients (13%) were discharged. If it took four or more minutes to initiate CPR, 25 of 204 patients (12%) were discharged (P<.001). Discharge rates were similar up to a definitive care time of eight minutes. If the time to definitive care was less than eight minutes, 78 of 197 patients (40%) were discharged. If the time to definitive care was eight or more minutes, 44 of 352 patients (13%) were discharged (P<.001).

Using multivariate analysis, time to initiation of CPR and time to definitive care were both predictive of outcome. Knowledge of access time or response time did not improve prediction of outcome. Other variables predictive of outcome such as age, bystander-initiated CPR, and type of emergency service (paramedic vs EMT) are reported elsewhere and when included in the multivariate analysis did not alter the findings.

The relationship of time to initiation of CPR and time to definitive care is additive. The highest survival rate occurred if both times were short (Fig 2). For 160 patients with CPR initiated within four minutes and definitive care provided within eight minutes, 69 (43%) were discharged. There were only two discharged patients (3%) among the 61 whose time to initiation of CPR and definitive care was greater than eight minutes.

In the vast majority of instances, time to initiation of CPR was shorter than time to definitive care owing to initiation of CPR by bystanders or the first arriving EMT aid unit. Definitive care was provided later either by the second arriving paramedic unit or after the arrival at the hospital in those areas without paramedic services. The only exceptions were in the 37 instances when cardiac arrest occurred after arrival of the paramedics and the patient received almost instantaneous definitive care (eg, defibrillation). Of these 37 patients, 16 (43%) were eventually discharged.

**COMMENT**

Our study results demonstrated two critical time components associated with successful outcome from out-of-hospital cardiac arrest. Previously published reports have seldom reported the resuscitation rate in relation to time to initiation of CPR and time to definitive care. Usually, only response times, which do not give a precise enough picture of the time from collapse to administration of care, are reported. The lack of precision is not surprising. Response time alone says nothing about when

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CPR is initiated and in instances of bystander-initiated CPR, which in the study was 29% of the incidents, cannot demonstrate the rapid initiation of CPR. Similarly, access time alone merely reflects the time to reach an emergency agency and does not indicate when CPR was initiated. The lack of discriminating time measurement could partially explain the wide variation in reported discharge rates: 6% to 24%.

Furthermore, presenting a summary discharge rate obscures the importance of times. By stratifying time and measuring outcome, the critical relationship between time and outcome emerges.

Determination of access time and time to initiation of CPR in bystander-initiated resuscitations involves subjective reports by bystanders. Time estimates, although usually determined by the first arriving emergency unit before knowledge of the outcome, certainly are colored by the emotionally charged resuscitation attempt. Despite the subjective nature of the estimate, we could detect no systematic bias; in other words, the average times were similar in the various fire districts and paramedic service areas. Unwitnessed cardiac arrest were purposely excluded from the analysis, since a precise time of collapse could not be determined. That survival from unwitnessed cardiac arrest was only 4% compared with 22% for witnessed events suggests another factor that should be taken into account when evaluating program effectiveness or comparing discharge rates of various programs.

Time to initiation of CPR and time to definitive care are jointly important. One short time without the other will not be successful. Much as CPR alone is not lifesaving, definitive care, even if delayed only as long as eight minutes, is not likely to be lifesaving unless CPR has been initiated quickly. The data suggest that early initiation of CPR can buy several additional minutes of time before definitive care must be provided if the patient is to survive.

The variables of time to definitive care actually include two intervals: time to initiation of CPR and time from CPR to definitive care. The variable was purposely constructed in this manner to anchor it to the moment of collapse. If time from CPR to definitive care is substituted for time to definitive care, the findings remain unchanged. From a program planning perspective, realistic options exist to improve the times to initiation of CPR and definitive care.

The options to improve the time to initiation of CPR include increasing the number of aid cars staffed with EMTs or increasing the number of citizens trained in CPR. The latter is economically the more feasible option. Seattle has pioneered the concept of citizen CPR training and has trained approximately 100,000 citizens (20% of the population), a factor that contributes to the high discharge rate following cardiac arrest in Seattle. Citizen CPR training can be performed inexpensively ($1.50 per person) in a three-hour session. The optimal number or target group of citizens to be trained is not well defined. For example, the option of training spouses of high-risk persons has not been attempted but could achieve the same results with less training investment.

The options to improve time to definitive care include increasing paramedic services or training EMTs to use defibrillators. Increasing (or initiating) paramedic programs would accomplish the goal of shortening time to definitive care but would do so at a high price. In suburban King County, the average annual cost to operate a paramedic unit serving 100,000 people is $275,000. Cost aside, unless paramedic units can achieve an average response time of less than eight minutes, they are not likely to be too successful. Hence, establishing paramedic programs in rural or semirural communities is not likely to save many cardiac arrest victims.

A more realistic option might be to train EMTs to use defibrillators. Fire department aid cars or private ambulances staffed with EMTs are present in most parts of the nation and hence would not require additional capital or salary outlays. The EMTs could either be trained to use a fail-safe machine (a rate detector that automatically discharges 335 watt seconds when the rate is greater than 200 and respirations are absent) or marketed for use by nonmedically trained people; another concept in the development stage is a ventricular fibrillation detector that automatically delivers a direct current shock) or be trained to recognize ventricular fibrillation and to use a defibrillator. Training EMTs to defibrillate is a new concept that has yet to be demonstrated effective on a communitywide basis and should be studied under carefully observed circumstances before widespread use.

It is unrealistic to assume that improved outcome of emergency medical services can be achieved simply by the addition of more EMT and paramedic units. Similarly, training thousands of citizens in CPR without coupling the training to a community program of emergency definitive care is practically futile. Half a program will not save many lives.

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References