Estimated Cost-Effectiveness of Dispatcher CPR Instruction via Telephone to Bystanders During Out-of-Hospital Ventricular Fibrillation

Terence D. Valenzuela, MD, FACEP, FACP,1 Daniel W. Spaite, MD, FACEP,1 Lani L. Clark,1 Harvey W. Meislin, MD, FACEP,1 Raymond O. Sayre2

Abstract

**Hypothesis:** Emergency cardiopulmonary resuscitation (CPR) instruction via telephone (ETCPR) is cost-effective compared to prehospital, emergency medical technician (EMT)/paramedic treatment alone of witnessed, ventricular fibrillation (VF) in adult patients. **Methods:** A total of 118 patients, age >18 years, with prehospital, witnessed ventricular fibrillation were studied. Patient data were extracted from hospital records, monitor-defibrillator recordings, paramedic reports, dispatching records, and telephone interviews with bystanders. No ETCPR was available during this period. The costs of ETCPR implementation were estimated retrospectively. Marginal cost of the paramedic service attributable to treatment of VF was calculated from fire department records. Years-of-life saved were estimated from age, gender, and race matched norms. **Results:** Of the 53 patients receiving bystander CPR (BCPR), 14 (26%) survived to hospital discharge versus 1/65 patients (6%) lacking BCPR. These groups did not differ significantly (p > .05) in age, EMS response times, or time from collapse to defibrillation. The mean time interval from collapse to CPR was significantly less for patients with BCPR (1.8 min) than for patients without BCPR (7.1 min). Had all patients received BCPR and survived at the rate of 0.26, 13 additional patients would have survived to hospital discharge. The cost per year-of-life saved by the EMS system with ETCPR would have been US$2,834 versus US$4,881 without ETCPR. The cost per additional year-of-life saved by ETCPR was estimated to be US$560 in patients experiencing out-of-hospital ventricular fibrillation. **Conclusion:** The use of ETCPR instruction of callers by 9-1-1 dispatchers potentially is a cost-effective addition to a two-tier EMS system for treatment of prehospital ventricular fibrillation.

**Key Words:** bystander CPR; cardiac arrest, survival; cardiopulmonary resuscitation (CPR); CPR telephone instruction; cost-effectiveness; prehospital; response times; ventricular fibrillation

**Introduction**

The time interval from collapse to the initiation of manual cardiopulmonary resuscitation (CPR) has been shown to critically affect outcome after out-of-hospital cardiac arrest due to ventricular fibrillation.1 This time interval is smaller in victims whose collapse is witnessed and who receive CPR first from bystanders compared to victims whose collapse is witnessed but who do not receive CPR until the arrival of the emergency personnel.2,3 Thus, interventions which increase the frequency with which bystanders at an arrest render BCPR to victims reasonably may be expected to increase survival.

Methods for instructing bystanders who telephone 9-1-1 to report an out-of-hospital cardiac arrest have been reported in recent years.4 Such approaches have the advantage of targeting CPR instruction to those needing to perform CPR, i.e., those reporting a patient in cardiac arrest.

1. The Arizona Emergency Medicine Research Center of the University of Arizona College of Medicine, Tucson, Ariz.
2. Tucson Fire Department, Tucson, Ariz.

Acknowledgment: This work was supported by a grant from the Flinn Foundation.
Correspondence: Terence D. Valenzuela, MD, Emergency Medicine, Arizona Health Sciences Center, 1501 N. Campbell Avenue, Tucson, AZ 85724 USA
While less costly and time consuming than community-wide programs to teach CPR techniques to an unselected lay population, programs that enable emergency dispatchers to give CPR instructions do require an initial and continuing investment of additional resources. An estimate was made of the potential cost-effectiveness in this EMS system comparing emergency dispatcher telephone CPR instruction (ETCPR) to its present operation without such instruction. The decision to develop the cost-effectiveness comparison was made due to local experience with the outcome of out-of-hospital cardiac arrest due to ventricular fibrillation.

Methods

Study Population: The study population consisted of 118 cases of out-of-hospital ventricular fibrillation, defined according to the recommendations of Eisenberg et al. In all cases, the collapse was witnessed by bystanders and emergency assistance summoned by use of the 9-1-1 telephone numbers. Cases were collected from October 1988 to July 1990.

Emergency Medical Services (EMS) System: Tucson, Arizona is a city with a population of 400,000 and area of approximately 150 square miles. The EMS system is two-tiered. The first tier consists of fire suppression vehicles staffed by firefighters trained to the level of basic emergency medical technicians. The second tier consists of firefighter-paramedics operating transport-capable emergency-rescue vehicles. Paramedic response interval (unit dispatch to arrival at scene) is <8 minutes in >90% of cases.

Clinical Data Collection: Cases were identified through the Sudden Death Project, an epidemiologic survey of all cases of out-of-hospital cardiopulmonary arrest carried out jointly by the Arizona Emergency Medicine Research Center and the Tucson Fire Department. Initial rhythm was determined by physician review of the oscilloscope recording made in the field by paramedics with recorder-equipped monitor defibrillators. Patient outcomes were collected from follow-up telephone interviews, letter questionnaires, and examination of hospital records. Survival was defined as discharge alive from hospital.

Cost Identification:Marginal costs in the EMS system associated with the treatment of all non-traumatic, out-of-hospital cardiopulmonary arrest were identified as described previously. Marginal costs were considered to be the additional cost during the study period, of operating a paramedic-level EMS system with a response time of eight minutes or less in 90% or more of cases versus an intermediate-level, emergency medical technician (EMT) EMS system with an eight-minute response time in less than 90% of cases. During the study period, Arizona Intermediate-EMTs were not certified to perform electrical defibrillation.

The marginal cost of operating an ETCPR program consists of the cost of initial training plus the ongoing cost of additional personnel in the dispatching center required for implementation of ETCPR. To determine the proportion of this cost attributable to cases of ventricular fibrillation, the marginal cost of treating all cases was multiplied by the proportion of all cases initially found in ventricular fibrillation whose collapse was witnessed. Costs of additional hospitalization in survivors versus non-survivors and gains/losses of economic productivity in survivors versus non-survivors were not considered in the analysis.

Cost Effectiveness: The perspective of the analysis is that of the EMS medical director. Endpoints for effectiveness were lives saved, as determined by survival to hospital discharge, and years-of-life saved. Years-of-life saved in survivors were extrapolated by assigning a life expectancy equal to that of the average United States resident of the same age, gender, and race. Estimated additional lives saved with dispatcher CPR instruction was calculated by assuming a survival rate in study patients who did not receive bystander CPR equal to that measured in study patients who did receive bystander CPR. These additional, potentially saveable lives were added to the number of survivors among patients who received spontaneous bystander CPR. Cost-effectiveness was expressed as cost-per-life saved and cost per year-of-life saved.

Statistical Methods: Means were compared using the student’s t-test; proportions were compared by chi-square analysis. A threshold for statistical significance of .05 was used.

Results

Of 118 cases of witnessed, out-of-hospital, cardiac arrest due to ventricular fibrillation
which occurred in adults during the study period. 53 (45%) received bystander CPR. There were 79 males and 39 females in the study population; the mean age was 66±12 years. Overall survival to hospital discharge was 18/118 (15%). Fourteen of the survivors were among patients receiving bystander CPR versus four survivors among patients not receiving bystander CPR. The interval from collapse to initiation of B CPR was 1.8±1.5 minutes versus 7.1±2.7 minutes in these two groups. Patients receiving bystander CPR did not differ significantly from those who did not in: age; response times of BLS and ALS level emergency personnel; or time from collapse to defibrillation.

The marginal cost of operating an ETCPR program was calculated to be $176,499. If patients in the study population who did not receive bystander CPR had received CPR in response to dispatcher telephone instructions, it was estimated that an additional 13 lives would have been saved (Table 1). Therefore, an ETCPR program would have reduced the cost per year-of-life saved for victims of out-of-hospital ventricular fibrillation in this EMS system from $4,881 (cost per year-of-life saved from witnessed ventricular fibrillation in a paramedic EMS system with >90% of responses <8 min) to $2,834 (cost per year-of-life from witnessed ventricular fibrillation saved by same EMS system with implemented ETCPR). The cost per projected additional year-of-life saved by ETCPR would have been $560.

The foregoing calculations rest on two assumptions: 1) The survival rate in patients receiving CPR as a result of ETCPR is the same as that observed in patients presently

<table>
<thead>
<tr>
<th>Cost of Treating Out-of-Hospital Ventricular Fibrillation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost of Treatment</strong></td>
</tr>
<tr>
<td>Without ETCPR</td>
</tr>
<tr>
<td>With ETCPR*</td>
</tr>
<tr>
<td><strong>Effectiveness Lives saved</strong></td>
</tr>
<tr>
<td>Without ETCPR</td>
</tr>
<tr>
<td>With ETCPR*</td>
</tr>
<tr>
<td><strong>Years-of-life saved</strong></td>
</tr>
<tr>
<td>Without ETCPR</td>
</tr>
<tr>
<td>With ETCPR*</td>
</tr>
<tr>
<td><strong>Cost-Effectiveness</strong></td>
</tr>
<tr>
<td><strong>Cost/life saved</strong></td>
</tr>
<tr>
<td>Without ETCPR</td>
</tr>
<tr>
<td>With ETCPR*</td>
</tr>
<tr>
<td><strong>Cost/year-of-life</strong></td>
</tr>
<tr>
<td>Without ETCPR</td>
</tr>
<tr>
<td>With ETCPR*</td>
</tr>
</tbody>
</table>

*Additional years-of-life saved by ETCPR estimated by assuming survival in witnessed cases of ventricular fibrillation where bystander CPR was not performed equal to that measured in cases where bystander CPR was performed. Additional cost associated with ETCPR was calculated from estimated additional dispatcher time required and dispatching center personnel costs.

Table 1—Estimated Cost-Effectiveness of Dispatcher CPR Instruction (ETCPR) for Patients in Ventricular Fibrillation

<table>
<thead>
<tr>
<th>Life Expectancy* (%)</th>
<th>0.00</th>
<th>0.05</th>
<th>0.12</th>
<th>0.18</th>
<th>0.26</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>$6,258</td>
<td>$4,881</td>
<td>$4,015</td>
<td>$3,420</td>
<td>$2,834</td>
</tr>
<tr>
<td>75</td>
<td>$6,258</td>
<td>$5,183</td>
<td>$4,422</td>
<td>$3,844</td>
<td>$3,286</td>
</tr>
<tr>
<td>50</td>
<td>$6,258</td>
<td>$5,498</td>
<td>$4,902</td>
<td>$4,422</td>
<td>$3,909</td>
</tr>
<tr>
<td>25</td>
<td>$6,258</td>
<td>$5,853</td>
<td>$6,258</td>
<td>$5,182</td>
<td>$4,802</td>
</tr>
</tbody>
</table>

*Life expectancy of potential survivors receiving CPR by dispatcher telephone instruction as a proportion of that in survivors receiving spontaneous bystander CPR.

Table 2—Sensitivity Analysis Using Survival Rate and Life Expectancy in CPR by Dispatcher
receiving bystander CPR in this system; 2) The length of survival in patients receiving CPR as a result of ETCPR is the same as that in patients currently receiving bystander CPR. Sensitivity analysis was performed by varying the expected survival rate and duration of survival among patients projected to receive CPR as a result of ETCPR (Table 2). The additional cost of ETCPR would raise the cost per year-of-life saved from its current $4,477 to $4,881, if no additional lives were saved among the patients currently not receiving bystander CPR. The "break-even" point in cost-effectiveness comes if survival in this group can be raised from its current 0.06 to 0.09 by ETCPR. The EMS system is more cost-effective with ETCPR whenever survival exceeds 0.09 in patients currently not receiving bystander CPR. If survival in patients receiving CPR because of dispatcher instructions equalled that seen in patients currently receiving bystander CPR, ETCPR would retain its advantage in cost-effectiveness unless the duration of survival in such patients is 25% or less than that of patients receiving bystander CPR.

Discussion

Two parameters of critical importance in the successful resuscitation of out-of-hospital ventricular fibrillation are the time intervals from collapse to initiation of manual cardiopulmonary resuscitation and to electrical defibrillation. Studies demonstrating a survival advantage to patients receiving bystander-initiated CPR confirm the import of interval to CPR by demonstrating that appropriately trained bystanders are able to initiate basic CPR faster than are emergency responders summoned by the 9-1-1 telephone system.

However, many patients whose arrests are witnessed, do not receive immediate CPR from bystanders. This group represents a population in which additional lives might be saved by the prehospital emergency medical services system with capabilities already in place.

Techniques have been described whereby emergency medical dispatchers may "couch" individuals by telephone, whether or not they have received prior instruction to perform basic CPR. A study of cardiac arrests in King County, Washington, before and after implementation of such a program showed an increase in bystander-initiated CPR from 45% to 56%. New programs in EMS, as in any other activity, require the justification of additional resources required for their implementation. Cost-effectiveness analysis is a method of assessing the return per unit of such resource investment. The cost-effectiveness of paramedic emergency medical services has been studied in the treatment of out-of-hospital cardiopulmonary arrest. In Tucson, it was decided to estimate the cost-effectiveness of dispatcher CPR instruction to individuals reporting cardiac arrest as defined according to recently proposed standard definitions. It was found that ETCPR has the potential to reduce the cost per year-of-life saved in victims of out-of-hospital ventricular fibrillation by 40%. The amount of money required, approximately $14,000 in start-up costs and $150,000 per year in 1989 for the ongoing, additional cost of dispatching personnel, is small relative to the budgets of fire departments in mid-sized cities such as Tucson, Arizona. Varying assumptions on the survival rate and life expectancy of survivors among patients currently not receiving bystander CPR indicates that ETCPR remains a cost-effective intervention, even if relatively pessimistic projections are made of these parameters. Moreover, it is possible that the cost-effectiveness of ETCPR has been underestimated, in that dispatchers doubtlessly will instruct callers to perform CPR on patients with other medical problems, e.g., drowning.

The study has limitations. The finding that additional lives would be saved by ETCPR and that such a program could reduce the cost per year-of-life saved to approximately 69% of its current level in this system, is based on the assumptions that survival in patients receiving CPR as a result of ETCPR would have a survival identical to that of patients currently receiving bystander CPR. Further, it was assumed that life expectancy in survivors due to ETCPR will be the same as that of survivors currently receiving bystander CPR. These assumptions must be tested prospectively in EMS systems where the implementation of ETCPR programs is planned. In this regard, the report of Eisenberg et al, noting no increase in overall out-of-hospital cardiac arrest survival (using the same case and survival definitions as this study) after implementation of an ETCPR program is disheartening. One interpretation of the King County report is that the CPR administered by previously untrained individuals in response to dispatcher CPR instruction is
ineffective. However, Carter et al assessed the quality of CPR performed by untrained volunteers following standardized dispatcher CPR instructions during simulated cardiac arrests, and found it not to be significantly less effective than that performed by previously CPR-trained volunteers.15 However, the King County study did detect a trend toward increased survival in ETCPR patients when the first EMS unit on scene had a response time greater than four minutes. It may be that in systems such as King County, which already have a high incidence of bystander CPR and excellent BLS and ALS response times, the benefits of ETCPR are less. Comparative information is needed from communities which traditionally have not had good success in the resuscitation of out-of-hospital cardiac arrest. A prospective, randomized, multi-center trial of dispatcher CPR instruction should be undertaken in jurisdictions with good (<8 minutes in >90% of cases) and low (<20%) incidence of bystander CPR.

**Conclusion**

Patients whose out-of-hospital cardiac arrest was witnessed, but who did not receive bystander CPR, represented a population in which additional lives might have been saved by emergency medical services systems. This experience indicates that addition of dispatcher CPR instruction via telephone to individuals reporting witnessed cardiac arrests would be an extremely cost-effective addition to a two-tier, urban, EMS system. Further data from communities which have not experienced high successful resuscitation rates for this medical problem and who implement ETCPR programs, are necessary to quantify the clinical benefit of this EMS innovation.

---

**References**


---

**Editorial Comment**

Norman Dinerman, MD, FACEP, Eastern Maine Medical Services, Bangor, Maine, USA—The article by Valenzuela et al makes a commendable attempt to assess the cost-effectiveness of providing dispatcher CPR instructions via telephone to bystanders during out-of-hospital ventricular fibrillation (VF) in a well-circumscribed patient population in a given system. The authors provide this well-articulated series of estimates for the Tucson system. They began with the documented observation that bystander-applied CPR is associated with increased survival of out-of-hospital patients with VF. They compared the potential cost-effectiveness of emergency dispatcher telephone CPR (ETCPR) to that without such instruction in the same system. The authors determined the marginal cost of operating an ETCPR program, and then the proportions of this cost attributable to cases of VF in which the patient's collapse was witnessed. They used two end-points: "lives saved," and "years-of-life saved." The latter is extrapolated by assigning a life expectancy value equal to that of the average U.S. resident of the same age, gender, and race. Additional "lives saved" was...
obtain by assuming a survival of study patients who did not receive bystander CPR as equal to that measured in study patients who did. Cost-effectiveness is expressed as cost per life saved and cost per year-of-life saved. They estimated that an additional 13 lives would have been saved had ETCPR been applied. Not unexpectedly, the authors concluded that the cost per year-of-life saved would have diminished from $4881 to $2834. They further concluded that ETCPR would retain advantages in cost-effectiveness, assuming survival of patients receiving CPR via dispatcher instruction would be equal to that of patients currently receiving bystander CPR, unless survival of the former group was 25% or less than that of patients receiving bystander CPR.

In their discussion, the authors candidly note the limitations of their study. These include the assumptions that survival of patients receiving CPR as a result of ETCPR would be identical to that of patients currently receiving bystander CPR, and that the life expectancy in such survivors would be equal to that of those survivors who had received CPR in the pre-ETCPR system. They note that there was not an increase in survival following implementation of ETCPR in King County, but point out that this may be explained by the ubiquitous availability of CPR in that system. The authors call for a prospective, randomized, multicenter trial of dispatcher CPR instruction in systems that have a response time and incidence of bystander CPR similar to that in Tucson.

The study contains many assumptions and estimates. No doubt, there are are more unknowns. The assumptions, estimates, and retrospective nature of this study may suggest to some that its place in the literature is undeserved. This would be a mistake. This article makes an important contribution to our knowledge of systems. It sharpens our awareness of the system costs of applying an intervention of increasing popularity in a system of known performance.

Beyond the clinical perspective of the authors is an inherent theme worthy of support. Clearly, the concept of a return on the investment of society’s resources should be applied continuously to every aspect of health care. For those of us who daily must interact with elected officials, fire chiefs, and other political species, this represents a reality that promises to confront us more aggressively during this decade. Indeed, the authors are quite prescient in the focus of this article, for the number of cost-effectiveness studies in the literature is small. Without this perspective or even an attempt to acknowledge its importance, the EMS Medical Director is likely to confront a progressively more hostile and skeptical community. Those Medical Directors who possess both the ability and willingness to consider the brutal reality of the cost-effectiveness of that for which society pays, stand to substantiate their credibility. Those who must pay for the medical dreams and technology that we so quickly embraced, have taken financially a far more sophisticated and less optimistic view of health care costs. Better that the clinician-researcher assume responsibility for analyzing these costs than those more saturnine colleagues elsewhere in the health care milieu.

This study also forces us to examine the many areas for which data still are lacking, such as the clinical effectiveness of survival from out-of-hospital, witnessed VF for patients who receive bystander CPR by those previously trained compared to those who are coached by dispatchers. There are few truths in resuscitation from cardiac arrest, and we should question the relative effectiveness and survival associated with these two methods. Thus, both the political reality and the overall effectiveness of bystander CPR are joined as objects for further study.

Perhaps more than anything, our departure from an era in which the value of our clinical intervention is divorced from its costs is signaled by articles of this type. Every physician involved in EMS System choreography quickly appreciates this fact. Dr. Valenzuela and his colleagues are to be congratulated for their efforts in analyzing an aspect of their system’s performance from this perspective. Nor is prehospital care alone in asking such cost/benefit questions. A recent article attempts to question the wisdom of applying CPR routinely to an in-hospital population.1,2 The prodigious expense ($60,000/survivor) and dismal outcome for selected patients argue strongly for greater scrutiny of the benefit of our clinical efforts. This article is a laudable attempt to ask hard questions during hard times. We will welcome more.

References