Predicting the Outcome of Unsuccessful Prehospital Advanced Cardiac Life Support

Arthur L. Kellermann, MD, MPH; Bela B. Hackman, MD; Grant Somes, PhD

Objective.—To determine if failure to achieve return of spontaneous circulation following prehospital advanced cardiac life support (ACLS) warrants termination of efforts at the scene.

Design.—Retrospective case series.

Setting.—Memphis, Tenn, a city of 610 337 people that is served by a fire department–based emergency medical service system. All city ambulances provide ACLS.

Patients.—Adult victims of out-of-hospital cardiac arrest due to heart disease.

Intervention.—All patients received prehospital ACLS according to the 1986 American Heart Association guidelines. Following prehospital ACLS, all patients were transported to the nearest hospital emergency department whether or not a pulse was restored in the field.

Main Outcome Measures.—Survival to hospital admission, survival to hospital discharge, and neurological status at discharge.

Results.—Over the 39-month study interval, the Memphis Fire Department treated 1068 victims of out-of-hospital cardiac arrest. Three hundred ten of these (29%) had return of spontaneous circulation prior to transport for some period. The remaining 758 patients (71%) never regained a pulse and were transported with ongoing cardiopulmonary resuscitation. Patients who had return of spontaneous circulation prior to transport were more likely to be admitted (69% vs 7.0%) and far more likely to be discharged alive (26.5% vs 0.4%) than patients who failed to respond to prehospital ACLS. Three patients who survived to hospital discharge despite failure to achieve return of spontaneous circulation prior to emergency medical service transport sustained their cardiac arrest after paramedic arrival. All three were discharged with moderate to severe cerebral disability.

Conclusion.—Rapid transport of adults who fail to respond to an adequate trial of prehospital ACLS does not result in meaningful rates of survival. In such cases, on-line emergency medical service physicians should authorize paramedics to cease efforts in the field.

(*JAMA*. 1993;270:1433-1436)

From the Divisions of Emergency Medicine (Drs Kellermann and Hackman) and Cardiology (Dr Hackman), Department of Internal Medicine, and the Department of Biostatistics and Epidemiology (Drs Kellermann and Somes), University of Tennessee, Memphis. Dr Kellermann is now with the Division of Emergency Medicine, Department of Surgery, Emory University, Atlanta, Ga.

Reprint requests to Division of Emergency Medicine, Department of Surgery, Emory University, 69 Butler St, Atlanta, GA 30303 (Dr Kellermann).

SUDDEN cardiac arrest claims the lives of approximately 250 000 US citizens each year.[1] Because collapse typically occurs within an hour of the onset of symptoms, the great majority of these events take place outside of a hospital.[1-3] Although studies show that prompt provision of prehospital cardiac care results in substantially higher rates of resuscitation and survival than rapid transport to the hospital,[1-4] uncertainty persists regarding when (or if) transport should be initiated if the patient remains in cardiac arrest.[5-7]

Eisenberg et al[3] and others[1,8] have identified a number of factors that appear to be associated with successful prehospital resuscitation and subsequent survival to hospital discharge. Some factors (such as the presence or absence of a witness to call for help) are largely matters of fate. Others, such as the timeliness of cardiopulmonary resuscitation (CPR) and prehospital advanced cardiac life support (ACLS), can be improved by refinements in the emergency medical service (EMS) system.[1-4,8-12] Recent research suggests that physiological parameters, such as coronary artery perfusion pressure,[13] end-tidal carbon dioxide concentration,[14] and the amplitude of the ventricular fibrillation wave form,[15] can also be used to predict successful resuscitation. However, none of these indicators are precise enough to support a decision to stop efforts in the field.

See also pp 1457 and 1471.

Between 1988 and 1992, four groups independently reported that patients who fail to respond to aggressive prehospital ACLS rarely survive to hospital discharge.[16-19] However, all of these studies were retrospective in nature and all were based on patients taken to a single institution. To verify the prognostic utility of this clinical rule, we prospectively identified all cases of out-of-

hospital cardiac arrest treated by our large urban EMS system over a 39-month period and followed up on each to determine the patient's hospital outcome.

METHODS

Study Site

The Memphis (Tenn) Fire Department (MFD) EMS Bureau is the sole provider of advanced life-support care to the citizens of Memphis (1990 population, 610 337). The MFD EMS Bureau operates 20 ACLS ambulances around the clock and normally staffs each vehicle with two paramedics. In addition to paramedic care, the MFD provides first-responder care through a network of 48 fire stations throughout the city. In cases of apparent or suspected cardiac arrest, the MFD alarm office simultaneously dispatches the nearest truck or engine company and the nearest available paramedic unit to the scene.

Standard Operating Procedure

During the study period, 40 MFD engine companies alternated carrying automated external defibrillators (Laerdal Heartstart 2000, Laerdal Medical Corp, Armonk, NY) as part of a prospective, controlled clinical trial. The remaining engine companies initiated CPR on arrival and continued to provide basic life support throughout the resuscitation attempt. Paramedic-staffed ambulances were immediately dispatched to each event and assumed responsibility for the patient on arrival. Following provision of ACLS, all patients were transported to the nearest hospital emergency department with ongoing treatment, whether or not return of spontaneous circulation (ROSC) was achieved.

Case Identification

All adult victims of out-of-hospital cardiac arrest treated by the MFD were identified. Cases of cardiac arrest due to trauma, drug overdose, and other noncardiac causes were excluded, as were cases involving children less than 18 years of age. Patients who were judged to be obviously dead at the scene prior to initiation of ACLS (eg, onset of rigor mortis or dependent lividity) were also excluded.

Primary surveillance was conducted by collecting a special cardiac resuscitation record from each paramedic unit. Secondary surveillance was conducted by reviewing all ambulance-trip tickets submitted to fire station headquarters to identify any unreported cases of cardiac arrest. In addition to these measures, EMS radio traffic was monitored by the city's regional communications center. Whenever a case was identified that was not documented by a paramedic report form, the responsible unit was contacted to minimize missing data. Engine company and EMS unit response times were subsequently verified by the MFD alarm office.

Table 1.—Factors Associated With Successful Return of Spontaneous Circulation (ROSC) in the Field

	ROSC (n=310)	No ROSC (n=758)	Odds Ratio	95% Confidence Interval	P
Mean age, y	63.5	64.6	...*	...	.19
Male, %	58.7	64.3	0.91	0.82-1.01	.09
Black, %	52.6	58.1	0.91	0.81-1.02	.10
Collapsed at home, %	69.3	70.6	0.98	0.90-1.07	.66
Collapse witnessed, %	71.9	56.5	1.27	1.14-1.42	<.01
Bystander CPR,† %	16.1	14.3	1.12	0.82-1.53	.47
Initial rhythm VF/VT	57.7	44.7	1.29	1.13-1.47	<.01
Firefighter response time, min	3.36	3.52	...	...	.22
Paramedic response time, min	5.68	5.91	...	...	.22
Intubated in field, %	88.1	88.6	0.99	0.95-1.04	.79
Survived to hospital admission, %	69.0	7.0	9.9	8.0-12.2	<.01
Survived to hospital discharge, %	26.5	0.4	66.7	37.5-118.9	<.01
No or mild neurological deficits, %	19.0	0	290.4	18.0-4682.7	<.01

*Ellipses indicate not applicable.
†CPR indicates cardiopulmonary resuscitation; VF, ventricular fibrillation; and VT, ventricular tachycardia.

Assessment of Outcome

Since all patients were transported following prehospital ACLS, the receiving hospitals were periodically contacted to identify those who survived to hospital admission. The length of stay and hospital outcome of each of these patients were also noted. Although survival to discharge was the primary outcome of interest, each patient's neurological status at hospital discharge was determined by contacting the patient's attending physician or a nurse familiar with the patient's condition. Cerebral performance was graded as normal (returned to premorbid status), mild impairment (slight impairment, but able to care for self), moderate impairment (requires assistance with many aspects of daily living), or severe impairment (requires assistance with all aspects of daily living).

Human Subjects Considerations

Our study involved no experimental interventions and did not require changes to existing community policy regarding EMS transport. Therefore, the requirement for informed consent was waived by the Institutional Review Board of the University of Tennessee, Memphis. Measures to protect the confidentiality of each study subject, his or her health care provider, and the hospital providing inpatient care were carefully maintained at all times.

Data Analysis

Since our study was designed to assess the predictive value of ROSC prior to EMS transport, group outcomes were initially compared on this basis. The sensitivity, specificity, positive predictive value, and negative predictive value of ROSC were then compared with corresponding values for other well-characterized predictors of cardiac arrest outcome. Patients who survived despite failure to achieve ROSC in the field were examined individually to see if their potential for survival could have been predicted at the time of EMS transport.

RESULTS

Between March 3, 1989, and June 8, 1992, the MFD treated 1068 victims of out-of-hospital cardiac arrest. A total of 310 of these (29%) were noted to have restoration of a pulse prior to EMS transport. The remaining 758 patients (71%) never regained a pulse and were transported at high speed to the nearest hospital emergency department.

An initial univariate analysis revealed that the age, sex, and race of patients who achieved ROSC at the scene were not significantly different than that of individuals who failed to respond to ACLS at the scene. Patients who were successfully resuscitated were more likely to have been witnessed (or heard) to collapse and these persons were more often found in a state of ventricular fibrillation. The EMS response times were generally fast in both groups, but successful prehospital resuscitations were not associated with significantly shorter response times than those reported in cases of refractory cardiac arrest (Table 1).

Patients who responded to prehospital ACLS were substantially more likely to be admitted to the hospital (69% vs 7.0%; odds ratio, 9.9; 95% confidence interval, 8.0 to 12.2) and were far more likely to survive to hospital discharge (26.5% vs 0.4%; odds ratio, 66.7; 95% confidence interval, 35.7 to 118.9) than

Table 2.—Criteria for Predicting Survival From Cardiac Arrest

	No.*	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
Age ≤80 y	1060	92.9	14.1	8.6	95.8
Female	1068	40.0	62.8	8.5	92.4
Witnessed collapse	922	79.0	40.7	11.4	95.3
Bystander CPR†	1044	21.4	85.7	11.6	92.6
Initial rhythm VF/VT	1068	74.1	53.8	12.2	96.0
Firefighter response ≤3 min	1022	65.4	45.8	9.4	93.9
Paramedic response ≤5 min	1068	64.7	52.3	10.5	94.5
ROSC prior to EMS transport	1068	96.5	76.8	26.5	99.6

*Number of observations with complete data.
†CPR indicates cardiopulmonary resuscitation; VF, ventricular fibrillation; VT, ventricular tachycardia; ROSC, return of spontaneous circulation; and EMS, emergency medical service.

patients who failed to respond to prehospital ACLS (Table 1). Eighty-two patients who were resuscitated in the field survived to hospital discharge, compared with only three of 758 patients who were transported in full cardiac arrest. These three patients who survived despite failure to achieve ROSC prior to transport had a spontaneous pulse at the time paramedics arrived but deteriorated to cardiac arrest prior to EMS transport. All three were eventually discharged with moderate to severe neurological deficits. No patient who was found in cardiac arrest and failed to achieve ROSC prior to transport survived to hospital discharge.

The predictive value of ROSC at the scene was then compared with those of other well-characterized criteria.[1-3,20] Although several were significantly linked with survival to hospital discharge, all but one misclassified a substantial number of cases. The only criterion confirmed to have a high degree of predictive value was failure to achieve ROSC prior to transport (Table 2).

COMMENT

Despite two decades of progress in the management of out-of-hospital cardiac arrest, a minority of victims survive to hospital discharge. Most die quickly as a result of refractory ventricular dysrhythmias, pulseless electrical activity, or asystole. Others succumb hours or even days later from cardiogenic shock, anoxic brain injury, multisystem failure, or other complications following cardiac arrest.[21] The emotional and financial costs of these deaths are high.

These grim statistics must be tempered, however, by the realization that many lives are saved by effective and timely prehospital cardiac care.[1] Highly proficient systems, such as the EMS systems of Seattle[22] and King County, Washington,[23] resuscitate more than half of all victims of out-of-hospital ventricular fibrillation in the field. The majority of those who survive are discharged from the hospital to their homes without neurological deficits.[23]

Unfortunately, the prognosis for patients who fail to respond to prehospital ACLS is far less favorable. In 1988, we analyzed the outcome of 281 consecutive patients who arrived at the Regional Medical Center at Memphis in refractory or recurrent cardiac arrest following unsuccessful prehospital ACLS.[16] Although 32 were resuscitated in the emergency department, only four (1.4%) survived to hospital discharge. Two had good neurological outcomes. Both had a palpable pulse and blood pressure while en route to the emergency department, but deteriorated to cardiac arrest shortly before arrival.

These results were soon replicated by case series from Royal Oak, Mich (181 cases, one survivor),[17] St Louis, Mo (211 cases, one survivor),[18] and Providence, RI (185 cases, no survivors).[19] A comprehensive review published in January 1993 identified a total of 16 survivors out of more than 3400 cases of refractory out-of-hospital cardiac arrest.[24] On the weight of findings such as these, the Emergency Cardiac Care Committee of the American Heart Association recently reached the following conclusion:

> Resuscitation may be discontinued in the prehospital setting when the patient is nonresuscitable after an adequate trial of ACLS.... Physician ambulance medical directors remain ultimately responsible for determination of death, and pronouncement of death in the field should have the concurrence of on-line medical control.... Return of spontaneous circulation for even a brief period is a positive prognostic sign and warrants consideration of transport to a hospital. Transport may also be warranted in special circumstances such as profound hypothermia.[1]

Our present study was undertaken to verify the predictive value of failure to achieve ROSC at the scene. Rather than restrict our analysis to patients who were brought to a single institution in cardiac arrest, we included every adult victim of cardiac arrest who was treated by our city's fire department–based EMS system over a 39-month study period. Rigorous data collection and quality assurance activity were maintained throughout the study and all patients were transported to the nearest hospital emergency department, regardless of their response to prehospital ACLS. Each patient's hospital outcome, length of stay, and neurological status at discharge were verified by contacting an attending physican or nurse at the receiving institution who was blinded to the study hypothesis.

Two potential limitations warrant comment. First, our study is based on data generated by a single EMS system. However, these observations are consistent with those reported from 10 other cities.[16-19,24] Community rates of cardiac arrest survival vary widely by locale, but most (if not all) of this difference is due to differing rates of prehospital resuscitation rather than intercity differences in emergency department or inpatient care.[25] Second, we cannot exclude the possibility that the weight of previously published reports led to a self-fulfilling prophecy. If our emergency department physicians and critical care specialists expected these patients to do poorly, the physicians may have treated them less aggressively than patients who responded to prehospital ACLS. However, none of the inpatient physicians at the nine hospitals who cared for these patients was aware of the study hypothesis. Furthermore, data collection was completed before the new guidelines of the American Heart Association were released.[1] We do not believe that physician behavior was influenced to a significant degree.

Our findings confirm that rapid transport of cardiac arrest patients who fail to respond to prehospital ACLS does not result in meaningful rates of survival to hospital discharge. Only three of 758 patients who failed to improve in the field following paramedic care survived to hospital discharge. All three were left with moderate to severe neurological deficits. Given the risks associated with high-speed transport, the substantial human resources required to continue resuscitative efforts in the emergency department, and the high cost of ultimately futile intensive care unit and other inpatient care, policies that mandate transport of refractory cardiac arrest patients to the hospital should be abandoned.[16,19,24]

This conclusion must be tempered by three caveats. First, our findings are based on cardiac arrest outcomes among adults. They should not be generalized to children. Second, exceptions should be made for individuals who are

profoundly hypothermic and possibly for patients who need an airway that cannot be secured at the scene. Finally, despite compelling evidence of the effectiveness of prehospital defibrillation, EMS providers in most small towns and many cities still lack the equipment needed to provide it.[26] In these communities, rapid transport for definitive care in the nearest emergency department remains the only option. This strategy is far less satisfactory than prehospital defibrillation and generally yields poor rates of cardiac arrest survival.[27]

Every victim of out-of-hospital cardiac arrest should receive a determined trial of prehospital ACLS unless he or she has requested that this treatment be withheld through a valid advance directive.[24] If, however, the victim does not achieve even transient ROSC with prehospital ACLS, his or her chances of survival are virtually nil. In such instances, paramedics should be authorized by an on-line EMS physician to cease efforts.[1,25] It will always be difficult for physicians to stop resuscitative efforts when the patient has the slightest chance of survival.[5] However, these slim odds must be tempered by concern for the safety of our prehospital personnel and the costs of rapid transport, extended resuscitation in the emergency department, and ultimately fruitless intensive care.

This study was supported by grant HS 06094 from the Agency for Health Care Policy and Research, Rockville, Md. Automated external defibrillators and other supplies were provided by Laerdal Medical Corp, Armonk, NY.

We are indebted to the men and women of the Memphis (Tenn) Fire Department for their service to the citizens of Memphis and their assistance with data collection. Peter Vitulli, MD, helped with case abstraction. LaGenna Betts and Carol Conway provided assistance with the preparation of the manuscript. Jane Scott, PhD, of the Agency for Health Care Policy and Research, served as project officer for the grant.

References

1. Emergency Cardiac Care Committee and Subcommittees, American Heart Association. Guidelines for cardiopulmonary resuscitation and emergency cardiac care. *JAMA.* 1992;268:2171-2183.
2. Cobb LA, Werner JA, Troughbaugh BG. Sudden cardiac death, I: a decade's experience with out-of-hospital resuscitation. *Mod Concepts Cardiovasc Dis.* 1980;49:31-36.
3. Eisenberg MS, Bergner L, Hallstrom AP, et al. *Sudden Cardiac Death in the Community.* New York, NY: Praeger Publishers; 1984.
4. Eisenberg MS, Copass MK, Hallstrom A, Cobb LA, Bergner L. Management of out-of-hospital cardiac arrest: failure of basic emergency medical technician services. *JAMA.* 1980;243:1049-1051.
5. Eisenberg MS, Cummins RO. Termination of CPR in the prehospital arena. *Ann Emerg Med.* 1985;14:1106-1107.
6. Kellermann AL, Hackman BB. Terminating unsuccessful advanced cardiac life support in the field. *Am J Emerg Med.* 1987;5:548-549.
7. Frank M. Should we terminate futile resuscitations in the field? can we afford not to? *Ann Emerg Med.* 1989;18:594-596.
8. Weaver WD, Cobb LA, Hallstrom AP, et al. Considerations for improving survival from out-of-hospital cardiac arrest. *Ann Emerg Med.* 1986;15:1181-1186.
9. Eisenberg MS, Copass MK, Hallstrom AP, et al. Treatment of out-of-hospital cardiac arrest with rapid defibrillation by emergency medical technicians. *N Engl J Med.* 1980;302:1379-1383.
10. Eisenberg MS, Hallstrom AP, Copass MD, Bergner L, Short F, Pierce J. Treatment of ventricular fibrillation: emergency medical technician defibrillation and paramedic services. *JAMA.* 1984;251:1723-1726.
11. Stults KR, Brown DD, Schug VL, et al. Prehospital defibrillation performed by emergency medical technicians in rural communities. *N Engl J Med.* 1984;310:219-223.
12. Cummins RO, Ornato JP, Thies WH, et al. Improving survival from sudden cardiac arrest: the 'chain of survival' concept: a statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. *Circulation.* 1991;83:1832-1847.
13. Paradis NA, Martin GB, Rivers EP, et al. Coronary perfusion pressure and the return of spontaneous circulation in human cardiopulmonary resuscitation. *JAMA.* 1990;263:1106-1113.
14. Sanders AB, Kern KB, Otto CW, Milander MM, Ewy GA. End-tidal carbon dioxide monitoring during cardiopulmonary resuscitation: a prognostic indicator for survival. *JAMA.* 1989;262:1347-1351.
15. Weaver WD, Cobb LA, Dennis D, Ray R, Hallstrom AP, Copass MK. Amplitude of ventricular fibrillation waveform and outcome after cardiac arrest. *Ann Intern Med.* 1985;102:53-55.
16. Kellermann AL, Staves DR, Hackman BB. In-hospital resuscitation following unsuccessful prehospital advanced cardiac life support: heroic efforts or an exercise in futility? *Ann Emerg Med.* 1988;17:589-594.
17. Bonnin MJ, Swar RA. Outcomes in unsuccessful field resuscitation attempts. *Ann Emerg Med.* 1989;18:507-512.
18. Lewis LM, Ruoff B, Rush C, Stothert JC. Is emergency department resuscitation of cardiac arrest victims who arrive pulseless worthwhile? *Am J Emerg Med.* 1990;8:118-120.
19. Gray WA, Capone RJ, Most AS. Unsuccessful emergency medical resuscitation: are continued efforts in the emergency department justified? *N Engl J Med.* 1991;325:1393-1398.
20. Longstreth WT, Cobb LA, Fahrenbruch CE, Copass MK. Does age affect outcomes of out-of-hospital cardiopulmonary resuscitation? *JAMA.* 1990;264:2109-2110.
21. Hackman BB, Kellermann AL. Cardiac arrest. In: Rakel RE, ed. *Conn's Current Therapy.* Philadelphia, Pa: WB Saunders Co; 1992:209-215.
22. Weaver WD, Hill D, Fahrenbruch CE, et al. Use of the automatic external defibrillator in the management of out-of-hospital cardiac arrest. *N Engl J Med.* 1988;319:661-666.
23. Cummins RO, Eisenberg MS, Litwin PE, Graves JR, Hearne TR, Hallstrom AP. Automatic external defibrillators used by emergency medical technicians: a controlled clinical trial. *JAMA.* 1987;257:1605-1610.
24. Kellermann AL. Criteria for dead-on-arrivals, prehospital termination of CPR and do-not-resuscitate orders. *Ann Emerg Med.* 1993;22:47-51.
25. Eisenberg MS, Horwood BT, Cummins RO, Reynolds-Haertle R, Hearne TR. Cardiac arrest and resuscitation: a tale of 29 cities. *Ann Emerg Med.* 1990;19:179-186.
26. Kerber RE. *Statement on Early Defibrillation From the Emergency Cardiac Care Committee, American Heart Association.* Dallas, Tex: American Heart Association; 1991.
27. Stults KR, Brown DD, Shug VL, Bean JA. Prehospital defibrillation performed by emergency medical technicians in rural communities. *N Engl J Med.* 1984;310:219-223.