CLINICAL INVESTIGATIONS

Derivation of a Termination-of-resuscitation Guideline for Emergency Medical Technicians Using Automated External Defibrillators

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Abstract

Objectives: To determine the association between characteristics of cardiac arrest and survival to hospital discharge following failed resuscitation by defibrillation-trained emergency medical technicians (EMT-Ds), and to propose an out-of-hospital termination-of-resuscitation (TOR) guideline for EMT-Ds. **Methods:** A 22-month retrospective review of 700 out-of-hospital primary cardiac arrest patients in a large emergency medical services (EMS) system who received exclusively EMT-D care. **Results:** Seven hundred primary cardiac arrest patients were identified. Follow-up was obtained in 662 cases (94.6%). Of these, 36 (5.4%) achieved a return of spontaneous circulation (ROSC) prior to transport. Among the 626 patients who failed to achieve ROSC at any time, two (0.3%) survived to discharge. Multivariate analysis showed that ROSC at any time had the strongest association with survival [odds ratio (OR) 45.5; 95% confidence interval (95% CI) = 8.5 to 243.7]. A shock prior to transport (OR 6.9; 95% CI = 1.2 to 40.3) and cardiac arrest witnessed by EMS personnel (OR 4.4; 95% CI = 1.0 to 18.5) were also independently associated with survival. These variables were incorporated into a TOR guideline. The guideline was 100% sensitive (95% CI = 99.1 to 100) in identifying survivors and had 100% negative predictive value (95% CI = 75.3 to 100) for identifying nonsurvivors of out-of-hospital cardiac arrest in the study population. **Conclusions:** In this EMS system, cardiac arrest patients may be considered for out-of-hospital TOR following EMT-D resuscitation attempts when there has been no ROSC, no shock has been given, and the arrest was not witnessed by EMS personnel. These guidelines require prospective validation. **Key words:** emergency medical services; cardiopulmonary resuscitation; resuscitation orders; medical ethics; automated external defibrillators. ACADEMIC EMERGENCY MEDICINE 2002; 9:671–678.

Over the last 15 years, several studies have assessed the effectiveness of training emergency medical technicians (EMT-Ds) in the skill of early defibrillation of out-of-hospital cardiac arrest patients in both urban and rural settings.[1–10] The current practice is to transport these patients to the nearest emergency department (ED) for definitive Advanced Cardiac Life Support (ACLS) care. However, emergency ambulance transport has many attendant hazards to motorists, pedestrians, and emergency medical services (EMS) personnel.[11,12] Emergency department resuscitation of transported patients in refractory cardiac arrest limits the availability of EMS personnel to care for other patients, increases patient waiting times, and decreases ED and hospital bed and equipment availability.[13] Transport and in-hospital ACLS care are also associated with considerable financial expense.[13–15]

The National Association of EMS Physicians (NAEMSP) recently had a position paper published entitled "Termination of Resuscitation in the Prehospital Setting for Adult Patients Suffering Nontraumatic Cardiac Arrest."[16] These guidelines outlined specific criteria for the termination of resuscitation (TOR) efforts in the out-of-hospital setting for patients who had received full ACLS care, which includes defibrillation, endotracheal intubation, intravenous (IV) access, and the administration of IV drugs such as epinephrine, atropine, and lidocaine.

The current American Heart Association guidelines for cardiopulmonary resuscitation (CPR) acknowledge that there is also a need to develop TOR

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protocols for EMT-Ds in situations where ACLS care is not rapidly available.[17] A suggestion was made that the absence of a "shockable" rhythm after an adequate trial of resuscitation could be the key criterion for such a guideline; however, we were unable to find any evidence in the medical literature to support this assertion.

To date, research[5,13,14,18–20] and literature reviews[21–23] supporting TOR guidelines have been limited to patients who received full out-of-hospital ACLS care. Termination-of-resuscitation guidelines need to be studied and defined for cardiac arrest patients who have not responded to EMT-D resuscitation. A TOR guideline for EMT-Ds is important since EMT-Ds provide a substantial proportion of out-of-hospital care in North America, especially in rural settings. A recent survey also indicated that several U.S. cities have EMS systems that consist in whole, or in part, of EMT-Ds.[24]

Accordingly, this study sought to determine the association between various characteristics of out-of-hospital cardiac arrest and survival in patients treated exclusively by EMT-Ds and to propose an out-of-hospital TOR guideline for EMT-Ds.

METHODS

Study Design. This was a retrospective review of all cases of out-of-hospital cardiac arrest during a 22-month period. The objective was to determine characteristics of arrest, survivors, and failed resuscitations in order to develop guidelines for termination of out-of-hospital arrests attended by EMT-Ds. This study was reviewed by and received approval from our institutional research ethics board.

Study Setting and Population. Our EMS system is situated in a large urban center with a population of more than 2.2 million citizens and a land mass of 632 square kilometers. It consists of a single ambulance service [approximately 500 EMT-Ds and 150 advanced life support (ALS) paramedics] and a single fire service (approximately 2,500 firefighter first responders trained in automated external defibrillation) under the medical direction of a single base hospital. Our EMS system responds to approximately 180,000 emergency calls annually, including 1,500 primary cardiac arrests, using a tiered response system in which the nearest fire service crew and ambulance service crew (EMT-D or ALS paramedic) are preferentially dispatched. In cases where an EMT-D crew is dispatched first, an ALS paramedic crew is dispatched only if the predicted computer-aided dispatch call–response interval is less than 8 minutes. Firefighters attend approximately 80% of all out-of-hospital cardiac arrests as first responders. EMT-Ds are the sole responding ambulance crew in 25% of cases, while the remainder of cardiac arrests are attended either by a single ALS crew or both an ALS crew and an EMT-D crew.

At the time of this review, graduating EMT-Ds received training in a two-semester community college course. They were trained in advanced first aid, basic trauma life support, and basic cardiac life support. Subsequent to this, they received further training in automated external defibrillation (16 hours), and the administration of aspirin (ASA), nitroglycerin spray, nebulized albuterol, glucagon, and subcutaneous epinephrine (16 hours) by the ambulance service and the base hospital. EMT-Ds who encounter a patient in cardiac arrest apply an automated external defibrillator (AED) that analyzes the cardiac rhythm and delivers a shock if appropriate. If the AED determines that a shock is not indicated, CPR (i.e., manual chest compressions with bag–valve–mask ventilation using an oropharyngeal airway) is performed for 1 minute before the AED analysis is repeated. Following three consecutive AED analyses that indicate a nonshockable cardiac rhythm, or after delivery of up to nine shocks by the defibrillator, EMT-Ds are required to continue CPR and to initiate transport to one of 22 receiving EDs in the region for further resuscitation efforts. Further shocks are administered during transport only if a patient who has regained spontaneous circulation subsequently loses it. EMT-Ds are trained to include prior defibrillation protocol actions taken by firefighters when deciding whether a transport indication has been reached.

We retrospectively reviewed all cases of out-of-hospital cardiac arrest with complete documentation that occurred in January 1998 and between May 1, 1998, and January 31, 2000. Case records between February 1998 and April 1998 were not available for review. Patients were excluded from the study if they were "obviously dead" (in rigor mortis with dependent lividity); their arrest was due to trauma, drowning, or drug overdose; they received any out-of-hospital ACLS care; they possessed a documented "do not resuscitate" directive; or they were less than 18 years of age.

Study Protocol. Data abstractors (DWM, FHA, JS) received a one-hour training session with practice using seven standardized cardiac arrest cases. Accuracy in data abstraction was reviewed by the principal investigator prior to the beginning of the study. Explicit criteria for case identification were discussed. Standardized data abstraction forms

TABLE 1. Characteristics of Eligible Patients According to Follow-up Status

Variable	Follow-up Complete (*n* = 662)	Lost to Follow-up (*n* = 38)
Age—mean (±SD)*	72.0 (±14.1) yr	77.7 (±11.1) yr
Gender—male	404 (61.0%)	19 (50.0%)
Arrest witnessed by bystander	264 (39.9%)	19 (50.0%)
Arrest witnessed by EMS	83 (12.5%)	6 (15.8%)
Shock given by defibrillator	167 (25.2%)	7 (18.4%)
Bystander CPR	106 (16.0%)	7 (18.4%)
ROSC in the field	36 (5.4%)	4 (10.5%)
Response interval—median (interquartile range)†	6.7 (3.2) min	6.7 (3.0) min

*n = 656 and 37.
†n = 596 and 36.
EMS = emergency medical services; CPR = cardiopulmonary resucitation; ROSC = return of spontaneous circulation.

were used in conjunction with a manual that described each data field. Weekly meetings were held to resolve ambiguous or unclear data. The data abstractors were aware that we sought to determine the proportion of cardiac arrest survivors in our case sample but not that a TOR guideline would be developed. Double data entry was completed on 14% of cases. An error rate of 1.4% was observed in a total of 945 fields.

Data were retrieved from ambulance service call reports, computer-aided dispatch records, fire service call reports, and AED recordings. Where possible, data abstraction conformed to the Utstein style for the reporting of cardiac arrests[25] and included: response interval (time from paramedic crew notification to the ambulance stopping on-scene); presumed etiology of the arrest (cardiac vs. non-cardiac); presence of witnesses (bystander or EMS personnel); presence or absence of a shockable cardiac rhythm prior to transport (defined according to whether a shock was given at any time either by a firefighter or an EMT-D prior to transport); presence of bystander CPR; and presence of any, including transient, return of spontaneous circulation (ROSC) prior to transport. Transport was defined as beginning with initial patient extrication away from the resuscitation scene.

Measures. After the out-of-hospital clinical data were abstracted, outcome data were obtained from the medical records departments of each receiving hospital. Patient outcomes were divided into three categories: 1) pronounced dead in the ED; 2) admitted to an intensive care or other hospital unit but subsequently died; or 3) admitted and survived to be discharged from hospital. Patients for whom hospitals were unable to provide outcome data were followed up with the Office of the Chief Coroner. The medical records departments and the coroner's office were blinded to all patient information except age, gender, name, date of birth, and date of cardiac arrest. Patients were declared lost to follow-up if outcome information could not be obtained from either the receiving hospital or the coroner.

Data Analysis. Statistical analysis was performed using SAS version 8.0.[26] Tests of association among categorical variables were conducted using chi-square or Fisher's exact tests, as appropriate; differences in median response intervals were analyzed using a Mann-Whitney U test and differences in means were evaluated using a Student's t-test. All comparisons were based on two-tailed tests. Odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated for the association of out-of-hospital variables with survival to hospital discharge. Multivariate logistic regression analysis was subsequently performed using variables that had a significant association with survival in the bivariate analyses. Variables that remained significantly associated with survival to hospital discharge were considered for the development of an EMT-D TOR guideline.

RESULTS

We reviewed 769 cases of out-of-hospital cardiac arrest where the only ambulance responders were EMT-Ds. Of these, 69 were excluded due to non-cardiac etiology of the arrest. Follow-up was achieved for 662 (94.6%) of the remaining 700 eligible cases. Table 1 describes the demographic and out-of-hospital characteristics of all eligible patients according to follow-up status. Patients for whom follow-up data were acquired were similar to those lost to follow-up in most aspects, but tended to be younger (mean age 72.0 years vs. 77.7 years, p = 0.02).

The disposition of all cases is shown in Figure 1. Of the 662 patients with complete follow-up, 36 (5.4%) achieved ROSC at some point in the field. Of these, seven (19.4%) died in the ED, 18 (50%) died after hospital admission, and 11 (30.5%) survived to hospital discharge. Of the 626 patients who failed to achieve ROSC, 588 (93.9%) died in the ED and 36 (5.8%) died following hospital admission. Only two of these 626 patients (0.3%; 95% CI = 0.04 to 1.2) survived to hospital discharge, one of whom was discharged with a good neurologic outcome. The other was admitted to a chronic care facility with severe cognitive and functional impairment.

Odds ratios for the associations between out-of-

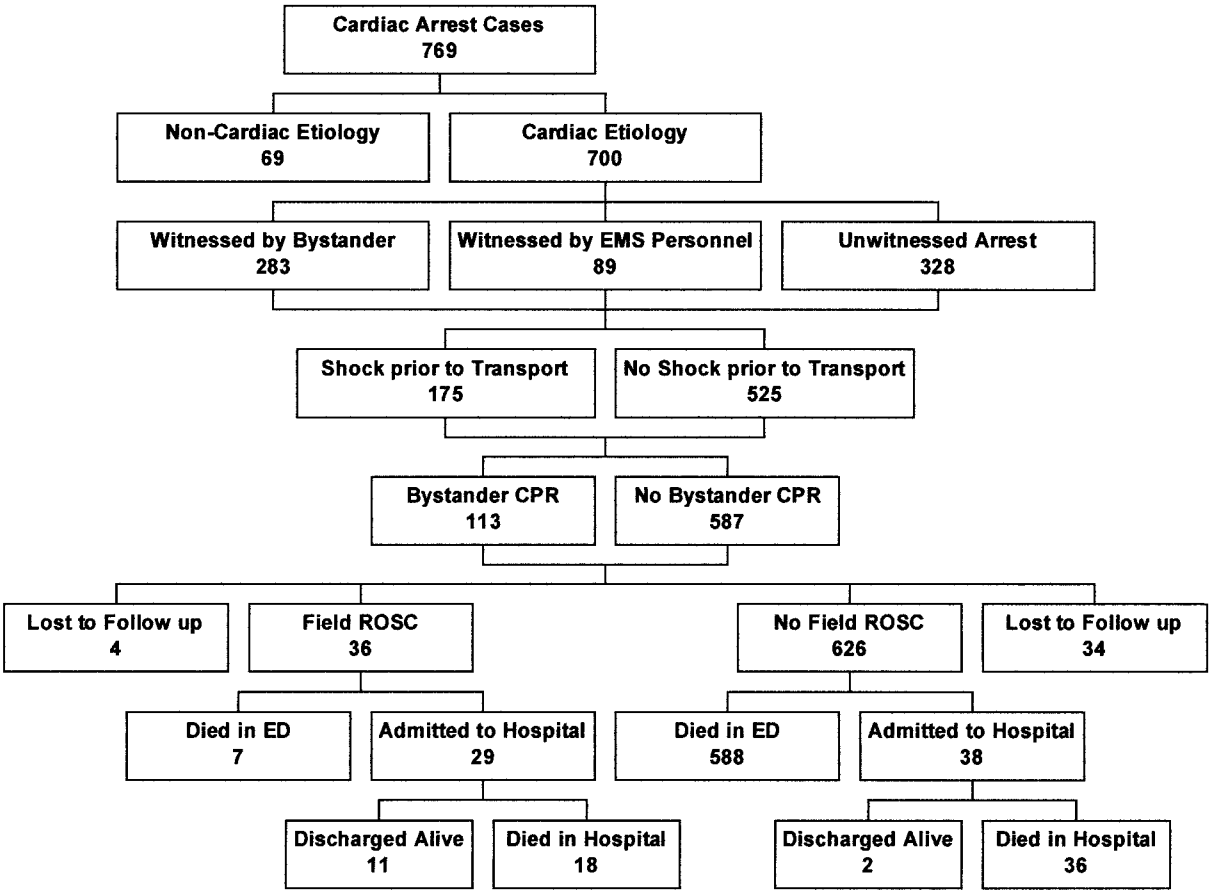

Figure 1. Disposition of primary cardiac arrest patients for whom resuscitation was attempted by defibrillation-trained emergency medical technicians (EMT-Ds). EMS = emergency medical services; CPR = cardiopulmonary resuscitation; ROSC = return of spontaneous circulation; ED = emergency department.

hospital cardiac arrest characteristics and survival to hospital discharge are shown in Figure 2. Of these, three were found to be significantly associated with survival: achievement of ROSC prior to transport (OR 137.3; 95% CI = 28.9 to 652.5); shock given prior to transport (OR 18.9; 95% CI = 4.2 to 86.5); and witnessed by EMS personnel (EMT-D or firefighter) (OR 8.8; 95% CI = 2.9 to 26.9). Bystander witness (OR 1.3; 95% CI = 0.4 to 3.9) and bystander CPR (OR 1.0; 95% CI = 0.2 to 4.4) were not associated with survival.

Multivariate logistic regression analysis of ROSC prior to transport (OR 45.5; 95% CI = 8.5 to 243.7), shock given prior to transport (OR 6.9; 95% CI = 1.2 to 40.3), and cardiac arrest witnessed by EMS personnel (OR 4.4; 95% CI = 1.0 to 18.5) demonstrated that each was independently associated with survival to hospital discharge.

We incorporated these three independent associations into a cardiac arrest TOR guideline for EMT-Ds (Fig. 3). This guideline proposes field pronouncement of cardiac arrest patients for whom there has been no ROSC achieved prior to transport, no shock has been given prior to transport, and the arrest was not witnessed by EMS personnel. All other patients would require transport for ongoing resuscitative efforts at a receiving ED. Retrospective application of this guideline to our sample (Fig. 4) indicated that all cardiac arrest victims who survived to discharge were included in the group identified as requiring transport (sensitivity = 100%; 95% CI = 99.1 to 100), and that no patient who would have been pronounced dead in the field survived to discharge (negative predictive value = 100%; 95% CI = 75.3 to 100).

DISCUSSION

There is ample evidence in the medical literature that cardiac arrest patients who fail to achieve ROSC after out-of-hospital ACLS care do not survive to hospital discharge, and that ED resuscitation efforts for these patients are futile and do not justify the associated risks and expenses that they incur.[5,13,14,18–23] However, these studies and the NAEMSP TOR guidelines[16] did not consider the situation where ACLS care is unavailable as part of the EMS response. To date (to the best of our

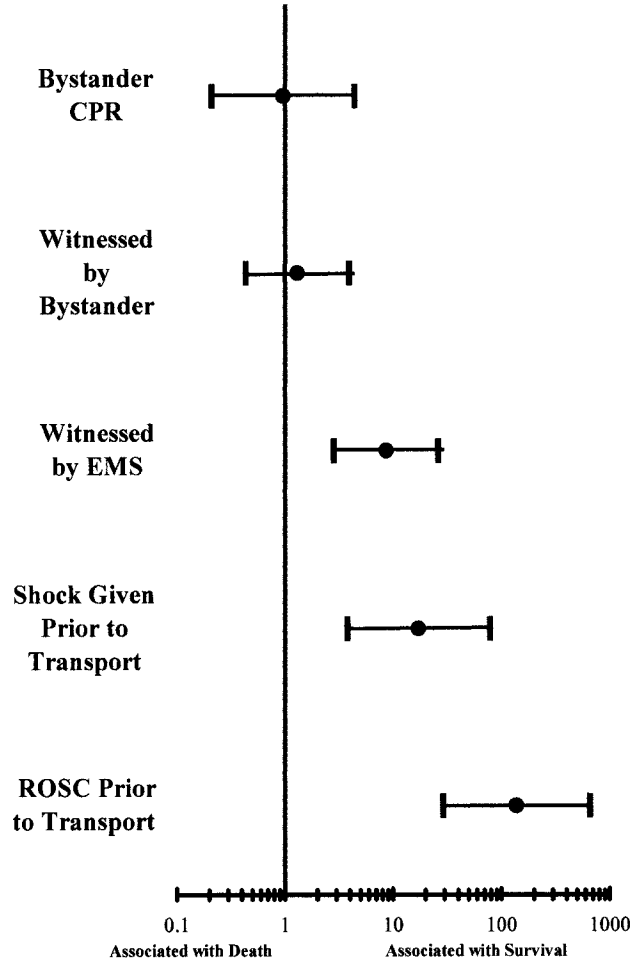

Figure 2. Odds ratios and 95% confidence intervals for cardiac arrest characteristics associated with survival to discharge. CPR = cardiopulmonary resuscitation; EMS = emergency medical services; ROSC = return of spontaneous circulation.

knowledge), no study has reported whether transport and continued ED resuscitation efforts are similarly futile when only EMT-D resuscitation is available. Current practice dictates that all cardiac arrest patients ought to be given ACLS care before resuscitation is discontinued; however, the benefit of such care, when administered in the ED following failed EMT-D resuscitation efforts, is unclear.

Our study retrospectively determined the proportion of survivors to hospital discharge among patients who failed to achieve ROSC in the field after EMT-D resuscitation, and were transported to an ED for ongoing resuscitation. We found that only two of these patients (2/626, 0.3%) survived to hospital discharge, only one of whom was discharged with good neurologic function. Each of these two patients received shocks prior to transport. Achievement of ROSC at any time prior to transport was found to be the factor most strongly associated with survival to hospital discharge, a finding also observed in a previously published study of failed out-of-hospital resuscitation among ACLS-treated cardiac arrest patients.[27] Thus, an argument could be made that transport of cardiac arrest patients refractory to EMT-D resuscitation for further ED resuscitation is futile.

Our data suggest that the likelihood of benefit of further resuscitation in such patients is less than 1%, which meets the widely cited definition of medical futility proposed by Schneiderman et al.[28] As such, there is merit in the development of an out-of-hospital TOR guideline for failed EMT-D resuscitation to reduce the costs associated with futile resuscitation efforts, to more efficiently allocate the resources of busy EMS systems and EDs, and to reduce the number of high-speed emergency ambulance transports. However, critics of definitions of futility that are based on a low, as opposed to zero, likelihood of survival could argue that to pronounce death in all patients who fail out-of-hospital EMT-D resuscitation would be an unacceptable violation of the autonomy of potential survivors, regardless of how few they may be in number.[29,30] Ideally, termination of resuscitation should be considered only for patients who have no chance of survival, rather than a low (i.e., <1%) chance of survival. Our finding of a small but non-zero probability survival in failed field resuscitation is common to several other TOR studies in the ALS literature where survival rates of 0.4%–1.9% have been documented.[5,14,19,20]

In the present study, we identified three cardiac arrest characteristics that were independently associated with survival to hospital discharge: ROSC prior to transport, a shock given prior to transport, and cardiac arrest witnessed by EMS personnel. A TOR guideline that was modeled on these independent associations successfully identified all nonsurvivors. It is noteworthy that bystander witness and bystander CPR were not associated with increased survival, contrary to the findings of a recent large report of an ambulance-based EMT-D system.[31] Perhaps this difference is accounted for by the use of firefighter first responders trained in automated external defibrillation in our system.

We have proposed an out-of-hospital TOR guideline for EMT-Ds that incorporates each of these three independent associations. This guideline would allow for the on-scene pronouncement of any adult patient where there has been no ROSC prior to transport, where no shock has been given, and where the cardiac arrest was not witnessed by EMS personnel. All other patients would be transported to an ED for further resuscitation. When applied to our study population, the guideline proved to be 100% sensitive (all potential survivors would have been transported) and achieved a 100% negative predictive value (field pronouncement would

Prehospital Cardiac Arrest Patients may be considered for Termination of Resuscitation in the Field following completion of EMT-D resuscitation attempts when:

1) **There has been no return of spontaneous circulation,**

AND

2) **No Shock has been given,**

AND

3) **The arrest was not witnessed by EMS personnel.**

All other patients require continued resuscitation and emergent transport to the nearest Emergency Department.

Figure 3. Termination of resuscitation guideline for defibrillation-trained emergency medical technicians (EMT-Ds). EMS = emergency medical services.

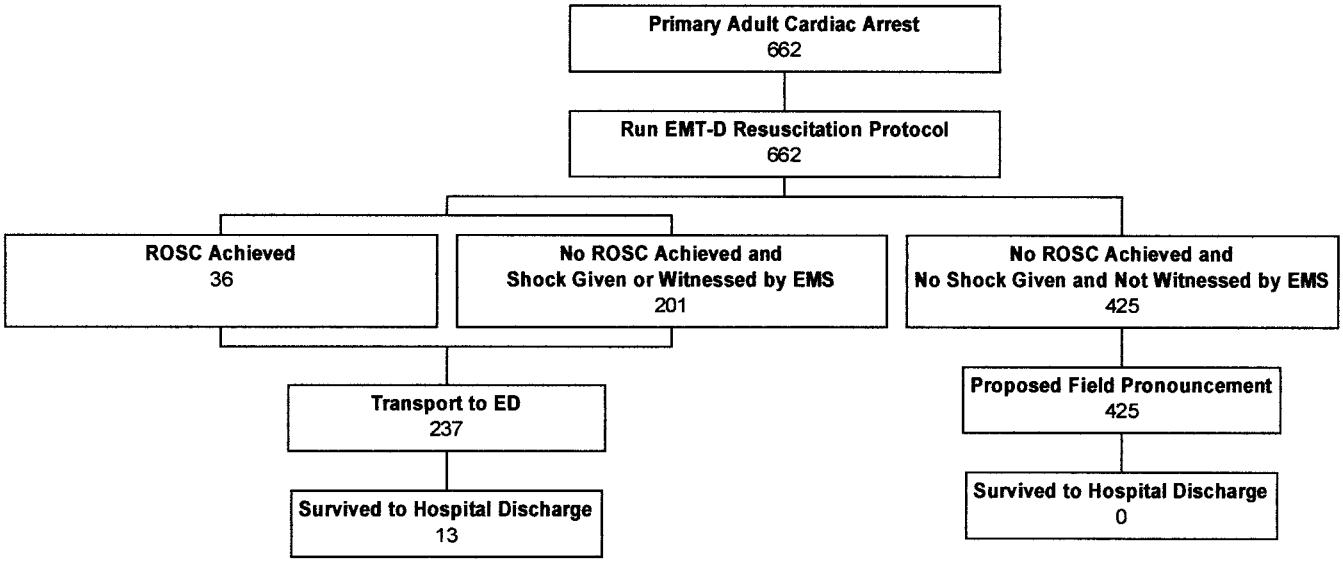

Figure 4. Performance of termination of resuscitation guideline for defibrillation-trained emergency medical technicians (EMT-Ds). ROSC = return of spontaneous circulation; EMS = emergency medical services; ED = emergency department.

have been carried out only among patients who had no chance of survival).

Application of this rule to our sample (Fig. 4) would have resulted in transport of only 237 (35.8%) of 662 patients, of whom 13 (5.5%) would have survived to hospital discharge. Currently, all of these patients are transported in our EMS system. Of the 626 patients who failed to achieve ROSC in the field, only 201 (30.3%) would have been transported, of whom two (1.0%) would have survived to hospital discharge.

LIMITATIONS

There are limitations to this study that warrant comment. First, we examined patients served by a single urban EMS system using local EMT-D resuscitation protocols that may not be identical to other systems. Second, the proportion of cardiac arrest survivors in our sample was low (1.9%) but consistent with other large urban centers such as New York City[32] and Chicago,[33] rural EMS settings,[6] and the province of Ontario.[32–34]

Third, we did not include EMS response intervals as a variable in our TOR guideline. The traditional response interval includes the time from "call-received to ambulance-arrival-at-scene" and does not account for the time taken to access a patient who may be remote from the location the ambulance stops. In addition, the time interval from "ambulance-arrival-at-scene to EMT-D-arrival-at-patient" is not routinely collected in a reliable manner. This interval may be prolonged for a number of reasons. For example, in an urban setting with high-rise

buildings, the vertical response interval can be significant.[35] Moreover, the outcome of an EMT-D encountering a shockable rhythm (i.e., giving a shock) or achieving ROSC is largely dependent on the lapsed time from the onset of cardiac arrest. It is likely that prolonged response intervals are a surrogate outcome for absence of a shockable rhythm or a ROSC. Since we found that giving a shock and ROSC were independent predictors of survival, we do not believe that adding a defined response interval to our TOR guideline would be useful. We agree with the NAEMSP assertion that response intervals are often hard to define and, although they are associated with poor outcomes, they should not be used as criteria for termination of resuscitation.[16] We believe that this guideline would be applicable in rural EMS systems where response intervals are likely to be prolonged and therefore giving a shock or achieving ROSC is even less likely.

Fourth, we limited our sample to patients who received exclusively EMT-D care. It is possible that some cases may not have been reported to us and that our sample was not representative of all cardiac arrest patients encountered by our EMS system. Finally, as with any retrospective study, the proposed EMT-D TOR guideline requires prospective validation before it should be implemented. Validation of this guideline should focus on ensuring a clinically acceptable lower limit to the 95% confidence interval for the negative predictive value to satisfy the EMS community that no patient who would be pronounced dead in the field would have survived to discharge.

CONCLUSIONS

In our study, only 0.3% of out-of-hospital primary cardiac arrest patients who failed to achieve a ROSC following EMT-D resuscitation survived to be discharged. Achievement of ROSC at any time prior to transport demonstrated the greatest association with survival. Administration of a shock prior to transport and cardiac arrest witnessed by EMS personnel were also independently associated with survival. We propose that patients in cardiac arrest be considered for out-of-hospital termination of resuscitation where there has been no ROSC, no shock was given, and the arrest was not witnessed by EMS personnel.

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