Validation of 3 Termination of Resuscitation Criteria for Good Neurologic Survival After Out-of-Hospital Cardiac Arrest

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Study objective: Several termination of resuscitation criteria have been proposed to identify patients who will not survive to hospital discharge after out-of-hospital cardiac arrest. However, only 1 set has been derived to specifically predict survival to hospital discharge with good neurologic function. The objectives of this study were to externally validate the basic life support (BLS) termination of resuscitation, advanced life support (ALS) termination of resuscitation, and neurologic termination of resuscitation criteria and compare their abilities to predict survival to hospital discharge with good neurologic function after out-of-hospital cardiac arrest.

Methods: This was a secondary analysis of the Denver Cardiac Arrest Registry. Consecutive adult nontraumatic cardiac arrest patients in Denver County from January 1, 2003, through December 31, 2004, were included in the study. The BLS termination of resuscitation, ALS termination of resuscitation, and neurologic termination of resuscitation criteria were applied to the cohort, and their predictive proportions and 95% confidence intervals (CIs) were calculated for each set of criteria.

Results: Of the 715 patients included in this study, the median age was 65 years (interquartile range 52 to 78 years), and 69% were male patients. In addition, 223 (31%) had return of spontaneous circulation, 175 (24%) survived to hospital admission, 58 (8%) survived to hospital discharge, and 42 (6%) survived to hospital discharge with good neurologic function. The proportion of patients with good neurologic survival to hospital discharge correctly identified for continued resuscitation was 100% (95% CI 92% to 100%) for all 3 termination of resuscitation criteria. The proportion of patients with poor neurologic survival to hospital discharge or no survival to hospital discharge correctly identified as eligible for termination of resuscitation was 36% (95% CI 32% to 40%) with the BLS termination of resuscitation criteria, 25% (95% CI 22% to 29%) with the ALS termination of resuscitation criteria, and 6% (95% CI 4% to 8%) with the neurologic termination of resuscitation criteria. Use of the BLS termination of resuscitation criteria would have reduced transport of the largest number of patients.

Conclusion: All 3 termination of resuscitation criteria had equally high abilities to identify patients requiring continued resuscitation. The BLS termination of resuscitation criteria, however, had the best combined ability to predict good neurologic survival and poor neurologic survival or death. These findings and the relative simplicity of the BLS termination of resuscitation criteria support their use. [Ann Emerg Med. 2009;54:239-247.]

INTRODUCTION

Out-of-hospital cardiac arrest is a significant public health issue in the US. Approximately 165,000 arrests occur annually in the US and only approximately 6% of those for whom resuscitation is attempted survive hospital discharge.1 Characteristics associated with survival to hospital discharge have been described and include activation of emergency medical services (EMS), early application of cardiopulmonary resuscitation, quick defibrillation, return of spontaneous circulation, and emergency medical services dispatch time.2-4 In the emergency setting, a generally strong association exists between survival to hospital discharge and survival to hospital discharge with good neurologic function.5,6 However, a high burden of resource use, especially in cases with poor neurologic function, exists in these patients.7-9 In an effort to better triage resuscitation efforts, several criteria have been developed to identify patients who are unlikely to survive to hospital discharge with good neurologic function.10-14 Characteristics that include rapid defibrillation, application of advanced cardiac life support (ACLS) countershock, and defibrillations from the time of the arrest are associated with poor neurologic survival to hospital discharge.15,16 Other criteria have focused specifically on the presence of pupillary reflexes,17-19 the absence of brainstem reflexes,20,21 and the presence of pupillary dilation at the time of resuscitation.22-24 In 2000, these characteristics were combined and translated into a probabilistic model termed the neurologic termination of resuscitation (NTR) criteria.25 The NTR criteria use a combination of pupillary dilation (not present in the vast majority of neurologically injured patients upon arrival at the hospital), absence of brainstem reflexes (not present in a significant number of patients with poor neurologic survival), and the need for mechanical ventilation (not always present in patients who deteriorate rapidly).26 The NTR results in a high sensitivity (98% confidence interval [CI] 96%-99%) and a low positive predictive value (74% CI 59%-85%) for predicting poor neurologic survival to hospital discharge.25,27 We evaluated the NTR criteria because they are simple to implement and provide the possibility of reducing transport of the largest number of patients.28
Termination of Resuscitation Criteria and Neurologic Outcome

Ruygrok, Byyny & Haukoos

Editor’s Capsule Summary

What is already known on this topic
Termination of resuscitation criteria can be used to streamline emergency medical services by curtailing resuscitation when there is no chance of survival with good neurologic outcome.

What question this study addressed
How do 3 existing rules (basic life support [BLS], advanced life support, and neurologic) compare in predicting neurologic function after out-of-hospital cardiac arrest?

What this study adds to our knowledge
In this retrospective analysis of 715 cardiac arrest victims, all rules identified the 42 patients who survived with good neurologic outcome. The BLS rule had the highest specificity.

How this might change clinical practice
This article provides further support for the use of termination of resuscitation rules in the field. In this small study, the BLS rule performed best.

good or poor neurologic outcomes, as opposed to only predicting survival to hospital discharge. Of the 3 rules derived in that investigation, the rule with the best combined sensitivity and specificity for predicting good neurologic survival included the following variables: bystander- or EMS-witnessed arrest, age younger than 78 years, or ventricular fibrillation/pulseless ventricular tachycardia or pulseless electrical activity as the initial arrest rhythm.18 This rule, however, has not been externally validated or compared with other termination of resuscitation criteria.

Because the neurologic termination of resuscitation rule was defined to specifically predict good neurologic survival (as defined by a Glasgow Coma Scale score ≥14),18 we hypothesized that it would be equal to or better than the BLS or ALS termination of resuscitation criteria for predicting good neurologic outcomes in patients who experience out-of-hospital cardiac arrest. The objectives of this study, therefore, were to externally validate the BLS termination of resuscitation, ALS termination of resuscitation, and neurologic termination of resuscitation criteria and compare their abilities to predict survival to hospital discharge with good neurologic function after out-of-hospital cardiac arrest.

MATERIALS AND METHODS

This study was approved by the institutional review boards of all 10 participating institutions and met criteria for exemption from informed consent in all instances.

Study Design

This was a secondary analysis of the Denver Cardiac Arrest Registry. This registry includes consecutive adult patients who experienced nontraumatic out-of-hospital cardiac arrest in Denver, CO. The registry was originally developed to estimate the incidence and proportion of survivors of adult, out-of-hospital cardiac arrests for the county of Denver.21

Setting and Selection of Participants

The study population included consecutive adult (age ≥18 years) patients who experienced nontraumatic out-of-hospital cardiac arrest in Denver County from January 1, 2003, through December 31, 2004. Denver County has a geographic area of approximately 150 square miles and has an estimated county population of 550,000 and an estimated metropolitan population of 2.3 million, according to 2004 census data.22

Out-of-hospital medical care in Denver consists of a 2-tiered response system. Fire-based first responders provide BLS, including use of automated external defibrillators, and paramedic second responders provide ALS. The Denver Health Paramedic Division is the primary EMS agency, responding to approximately 80,000 calls for emergency medical assistance annually, which accounts for approximately 97% of all calls in Denver. Although paramedics follow the American Heart Association’s ACLS Guidelines for performing ALS, they primarily use clinical judgment when determining whether to

resuscitation (CPR), and early defibrillation in patients with ventricular fibrillation or pulseless ventricular tachycardia.2,3 Other factors independently associated with survival include the patient’s age,4 the location of the arrest,5 an arrest witnessed by bystanders or EMS personnel,6 and return of spontaneous circulation before transport by paramedics.7 Conversely, patients with an initial arrest rhythm of asystole, pulseless electrical activity, or failure to respond to either basic life support (BLS) or advanced life support (ALS) in the out-of-hospital setting have uniformly dismal outcomes.3,8,9

Considering the incidence of out-of-hospital cardiac arrest and the resources used to treat these patients, a set of criteria to predict good neurologic survival to hospital discharge would be extremely useful. These criteria, if found to be highly predictive, would potentially help reduce the demand placed on EMS personnel, resource use, and the associated costs by providing guidance for termination of resuscitation in the out-of-hospital setting for individuals who will never recover neurologically.10

Several termination of resuscitation criteria have been proposed.1,11-18 The BLS termination of resuscitation criteria and the ALS termination of resuscitation criteria have been studied most extensively and have been shown to identify those who will survive to hospital discharge.17,19,20 Neither were derived with the intent to predict meaningful neurologic outcomes. However, in another study, 3 clinical prediction rules were developed to specifically predict neurologic outcomes after out-of-hospital cardiac arrest.18 To our knowledge, these rules represent the first and only attempt to derive criteria to predict
initiate resuscitation. Patients are transported to 10 acute-care adult receiving hospitals in Denver, and all 10 hospitals participated in this study. At the time of this study, 2 of the 10 hospitals were academic medical centers, 3 served as Level I trauma centers, and 8 functioned as cardiac care referral centers. The median annual emergency department (ED) census of these hospitals is approximately 49,000 (range 17,000 to 72,000).

Data Collection and Processing
The Denver Cardiac Arrest Registry was developed with standardized retrospective data collection methodology. Consecutive cardiac arrest patients were identified from the Denver Paramedic response database, which includes all data collected during the out-of-hospital patient encounter for all patients responded to by Denver paramedics. Beginning in December 2002, all out-of-hospital data were collected with portable laptop computers (Panasonic Toughbook; Panasonic Corporation, Secaucus, NJ) and electronic data entry, storage, and maintenance (HealthWare Solutions EMS Software; HealthWare Solutions, Arcata, CA). All out-of-hospital patient and arrest characteristics were collected prospectively and in real time by the paramedics.

To capture all cardiac arrest patients during the study period and to populate the registry, several database search strategies were performed. Patients were initially identified if they had any of the following: (1) a paramedic diagnosis of “cardiac arrest”; (2) use of epinephrine; (3) performance of basic or advanced airway techniques (eg, bag-valve-mask ventilation or intubation); (4) performance of CPR or defibrillation; or (5) absent vital signs. Trained research assistants examined each record to confirm the presence of cardiac arrest before final inclusion in the registry. Patients were excluded if they experienced trauma resulting in arrest or were younger than 18 years.

Out-of-hospital data were transferred into the registry, including each patient’s name and demographics (ie, date of birth, sex, race/ethnicity), the location of the arrest, whether the arrest was witnessed by a bystander or EMS personnel, whether bystander CPR was performed, the initial arrest rhythm, whether defibrillation was attempted, and the response, scene, and transport times (in minutes).

A closed-response data collection instrument was used to collect data for each patient. The instrument included the out-of-hospital data, as well as return of spontaneous circulation, survival to hospital admission, survival to hospital discharge, and the Cerebral Performance Category Scale score at discharge. The Cerebral Performance Category Scale score (Table 1) was chosen because of its use in the Utstein template. All out-of-hospital data were confirmed or corrected by trained research assistants using a standardized review process of all paramedic response records. Survival data were obtained with standardized medical record abstraction from each receiving hospital by trained physician abstractors or research assistants. All abstractors were blinded to the purpose of this study.

Three unique out-of-hospital cardiac arrest termination of resuscitation criteria were evaluated in this study (Figure 1). None of the termination of resuscitation criteria were derived in Denver or Colorado. The BLS termination of resuscitation criteria suggest termination of resuscitation for patients who meet all 3 of the following criteria: (1) not witnessed by EMS personnel; (2) no defibrillation attempted before transport; or (3) no return of spontaneous circulation before transport. The ALS termination of resuscitation criteria recommend termination of resuscitation for patients who meet all 4 of the following criteria: (1) not witnessed by a bystander or EMS personnel; (2) no bystander CPR performed; (3) no defibrillation attempted before transport; or (4) no return of spontaneous circulation before transport. The neurologic termination of resuscitation criteria propose termination of resuscitation for patients who meet the following criteria: (1) not witnessed by a bystander or EMS personnel; (2) patient aged 78 years or older; or (3) asystole as the initial arrest rhythm.

Outcome Measures
The primary outcome measure for this study was survival to hospital discharge with good neurologic function as defined by a Cerebral Performance Categories Scale score of 1 or 2. This level of neurologic function is consistent with sufficient cerebral function for independent activities of daily life. Because survival data were abstracted retrospectively by evaluating medical records and because Cerebral Performance Category

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### Table 1. Cerebral Performance Category Scale.

<table>
<thead>
<tr>
<th>CPC Scale</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Good cerebral performance: conscious, alert, able to work, might have mild neurologic or psychological deficit.</td>
</tr>
<tr>
<td>2</td>
<td>Moderate cerebral disability: conscious, sufficient cerebral function for independent activities of daily life. Able to work in sheltered environment.</td>
</tr>
<tr>
<td>3</td>
<td>Severe cerebral disability: conscious, dependent on others for daily support because of impaired brain function. Ranges from ambulatory state to severe dementia or paralysis.</td>
</tr>
<tr>
<td>4</td>
<td>Coma or vegetative state: any degree of coma without the presence of all brain death criteria. Unawareness, even if appears awake without interaction with environment; may have spontaneous eye opening and sleep/awake cycles. Cerebral unresponsiveness.</td>
</tr>
<tr>
<td>5</td>
<td>Brain death: apnea, areflexia, electroencephalographic silence, etc.</td>
</tr>
</tbody>
</table>

CPC, Cerebral Performance Categories.

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Scale scores are not routinely documented in these records, abstractors were specifically trained to estimate Cerebral Performance Category Scale scores according to the patient’s neurologic condition at discharge.

All abstractors were clinicians trained with a standardized approach by the principal investigator. Instructions were developed, tested, and refined before their implementation. The validity (using abstraction performed by the principal investigator as the criterion standard) and reliability (using 2 blinded abstractors) of this process were assessed at 2 of the 10 hospitals (Denver Health Medical Center and the University of Colorado Hospital) before initiation of abstraction at the other 8 sites.

Primary Data Analysis and Statistical Analyses
All data were either electronically transferred or manually entered into an electronic database (Microsoft Access; Microsoft Corporation, Redmond, WA). The data set was cleaned and deidentified, and all data were transferred into native SAS or Stata formats with translational software (dfPower DBMS/Copy; DataFlux Corporation, Cary, NC). All statistical analyses were performed with SAS, version 9.1 (SAS Institute, Inc., Cary, NC) or Stata, version 10 (StataCorp, College Station, TX).

Descriptive analyses were performed on all variables. Bivariate statistical tests were performed with the Wilcoxon rank sum test, Fisher’s exact test, or \( \kappa \), where appropriate. Proportions and their respective 95% confidence intervals (CIs) were calculated for each set of termination of resuscitation criteria. For those variables with missing data, sensitivity analyses were performed to estimate their potential influence on each criterion’s predictive ability. The age criterion for the neurologic termination of resuscitation rule was also rounded to 80 years to improve its applicability, and the predictive ability of this rounded rule was also calculated. No corrections were made for multiple comparisons, and \( P<.05 \) was used to define statistical significance.

RESULTS
During the study period, 1,985 adult patients experienced nontraumatic out-of-hospital cardiac arrest. Of these, paramedics attempted resuscitation on 715 (36%), and this group represents our study sample. The median age was 65 years (IQR 52 to 78 years) and 69% were male patients. In addition, 41% of arrests were witnessed by bystanders, 8% were witnessed by EMS personnel, 25% of patients received bystander CPR, and 30% of patients had ventricular fibrillation or pulseless ventricular tachycardia as their initial rhythms. Of the 715 patients, 223 (31%; 95% CI 28% to 35%) had return of spontaneous circulation, 175 (24%; 95% CI 21% to 28%) survived to hospital admission, 58 (8%; 95% CI 6% to 10%) survived to hospital discharge, and 42 (6%; 95% CI 4% to 8%)
survived to hospital discharge with good neurologic function (Table 2). Overall agreement for determining good neurologic function was 80%, and the weighted $k$ for assessing neurologic function was 0.83.

Age, whether the arrest was witnessed, the initial arrest rhythm, whether defibrillation was attempted, use of an automated external defibrillator, and the transport time to the hospital were statistically associated with good neurologic survival to hospital discharge. Conversely, sex, whether bystander CPR was performed, response time, scene time, and the total out-of-hospital time were not statistically associated with good neurologic survival to hospital discharge (Table 2).

The proportion of patients with good neurologic survival to hospital discharge correctly identified for continued resuscitation was 100% (95% CI 92% to 100%) for all 3 termination of resuscitation criteria. The proportion of patients with poor neurologic survival to hospital discharge or no survival to hospital discharge correctly identified as eligible for termination of resuscitation was 36% (95% CI 32% to 40%) with the BLS termination of resuscitation criteria, 25% (95% CI 22% to 29%) with the ALS termination of resuscitation criteria, and 6% (95% CI 4% to 8%) with the neurologic termination of resuscitation criteria (Table 3). Of the 715 patients, 231 (32%) met all BLS termination of resuscitation criteria, 162 (23%) met all ALS termination of resuscitation criteria, and 39 (5%) met all neurologic termination of resuscitation criteria (Table 4). By not meeting at least 1 criterion, these patients would have been transported to a hospital for further resuscitation. Assuming all patients who receive attempted resuscitation are transported to the hospital, when applied to all the patients in our cohort, the BLS termination of resuscitation criteria would have reduced the

### Table 2. Patient characteristics associated with survival to hospital discharge with good neurologic function after out-of-hospital cardiac arrest.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Good NEURO Survival*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>55 (45-66)</td>
<td>66 (52-78)</td>
</tr>
<tr>
<td>Male sex</td>
<td>32/42 (76)</td>
<td>460/671 (69)</td>
</tr>
<tr>
<td>Initial rhythm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asystole</td>
<td>2/38 (5)</td>
<td>305/659 (46)</td>
</tr>
<tr>
<td>PEA</td>
<td>4/38 (11)</td>
<td>177/659 (27)</td>
</tr>
<tr>
<td>VF/pVT</td>
<td>32/38 (84)</td>
<td>177/659 (27)</td>
</tr>
<tr>
<td>Witnessed arrest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>28/42 (67)</td>
<td>263/673 (39)</td>
</tr>
<tr>
<td>No</td>
<td>6/42 (14)</td>
<td>361/673 (54)</td>
</tr>
<tr>
<td>EMS</td>
<td>8/42 (19)</td>
<td>49/673 (7)</td>
</tr>
<tr>
<td>Bystander CPR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>12/42 (29)</td>
<td>169/673 (25)</td>
</tr>
<tr>
<td>No</td>
<td>30/42 (71)</td>
<td>504/673 (75)</td>
</tr>
<tr>
<td>Defibrillation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>31/42 (74)</td>
<td>271/671 (40)</td>
</tr>
<tr>
<td>No</td>
<td>11/42 (26)</td>
<td>400/671 (60)</td>
</tr>
<tr>
<td>AED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>8/42 (19)</td>
<td>61/673 (9)</td>
</tr>
<tr>
<td>No</td>
<td>34/42 (81)</td>
<td>612/673 (91)</td>
</tr>
<tr>
<td>Response time (min)</td>
<td>6 (4-9)</td>
<td>6 (4-8)</td>
</tr>
<tr>
<td>Scene time (min)</td>
<td>16 (14-19)</td>
<td>17 (13-22)</td>
</tr>
<tr>
<td>Transport time (min)</td>
<td>7 (5-10)</td>
<td>6 (4-7)</td>
</tr>
</tbody>
</table>

**NEURO,** Neurologic; **PEA,** pulseless electrical activity; **VF,** ventricular fibrillation; **pVT,** pulseless ventricular tachycardia; **AED,** automated external defibrillation. All continuous data are reported as medians with interquartile ranges.

*Good NEURO survival is defined as survival to hospital discharge with a CPC Scale score of 1 or 2.

### Table 3. Results of the external validation of the 3 termination of resuscitation criteria for the prediction of survival to hospital discharge with good neurologic function.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Proportion of Patients With Good NEURO SHD Correctly Identified for Continued Resuscitation</th>
<th>Proportion of Patients With Poor NEURO SHD or No SHD Correctly Identified as Eligible for TOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLS TOR</td>
<td>42/42 100 92-100</td>
<td>231/673 36 32-40</td>
</tr>
<tr>
<td>ALS TOR</td>
<td>42/42 100 92-100</td>
<td>162/673 25 22-29</td>
</tr>
<tr>
<td>NEURO TOR</td>
<td>42/42 100 92-100</td>
<td>39/673 6 4-8</td>
</tr>
</tbody>
</table>

**NEURO,** Neurologic; **SHD,** Survival to hospital discharge; **TOR,** termination of resuscitation; **BLS,** basic life support; **ALS,** advanced life support.

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number of patients transported to the hospital by 32% (95% CI 29% to 36%), the ALS termination of resuscitation criteria would have reduced the number of patients transported to the hospital by 23% (95% CI 20% to 26%), and the neurologic termination of resuscitation criteria would have reduced the number by 5% (95% CI 4% to 7%). No set of criteria would have failed to identify a patient who would have survived neurologically intact.

When the neurologic termination of resuscitation age criterion was rounded to 80 years, the proportion of patients with good neurologic survival to hospital discharge correctly identified for continued resuscitation remained 100% (95% CI 92% to 100%), and the proportion of patients with poor neurologic survival to hospital discharge or no survival to hospital discharge correctly identified as eligible for termination of resuscitation increased to 11% (95% CI 9% to 13%). Data were missing only for the following termination of resuscitation criteria variables: initial rhythm (n = 18), defibrillation (n = 2), and return of spontaneous circulation (n = 1). Sensitivity analyses of these missing data did not change the predictive abilities of any of the 3 termination of resuscitation criteria.

**LIMITATIONS**

This study has several potential limitations. Standardized abstraction methodology was used to address some of the limitations potentially introduced by using a retrospective study design. It was unlikely the paramedics were aware of any of the termination of resuscitation criteria and even more unlikely that they used any of the criteria in determining whether to terminate resuscitation. Selection bias was limited by incorporating consecutive patients who met criteria for inclusion within the study period. Given our initially broad search, it is unlikely that we failed to identify patients for inclusion. Additionally, Denver paramedics respond to approximately 97% of all calls within Denver County, making it highly probable that we obtained a representative sample of all arrests, even though we did not examine cases responded to by other EMS agencies. Patient outcomes may have also been affected as a result of inaccurate interpretation of cardiac rhythms, inaccurate resuscitation, or premature termination by treating medical personnel because of underlying beliefs of futility. However, all medical personnel are trained to use standard ALS guidelines. Misclassification bias may have also been introduced during assessment of neurologic outcomes by abstractors. However, we used standardized abstraction methodology, and abstraction agreement was excellent.

The study was also potentially limited by its size and geographic area. During the study period, 715 patients experienced an out-of-hospital cardiac arrest and underwent attempted resuscitation. Although the proportions for each criteria for predicting good neurologic survival to hospital discharge was 100%, the size of the study sample limited the precision of these estimates. Therefore, the lower limits of the CIs indicate that a small proportion of patients may be incorrectly identified for termination of resuscitation who would go on to survive to hospital discharge with good neurologic function. Although this study was multicentered, including 10 acute-care receiving hospitals in Denver, a larger sample size and broader geographic range may be needed before these findings can be more broadly generalized. Finally, it is possible that recent advancements in the treatment of post–cardiac arrest (eg, mild therapeutic hypothermia or extracorporeal membrane oxygenation) will improve neurologic outcomes and alter the results reported in this study.
**DISCUSSION**

Despite efforts to reduce morbidity and mortality among patients who experience out-of-hospital cardiac arrest, this clinical entity remains a substantial public health problem. Our understanding of the pathophysiology of cardiac arrest continues to evolve, and the number, sequence, and quality of interventions performed provide for the opportunity to improve outcomes. However, survival among unselected cardiac arrest patients has remained poor and relatively constant during the past several decades.\(^{26-30}\) Additionally, as the incidence of ventricular fibrillation/pulseless ventricular tachycardia decreases, survival will continue to primarily depend on how quickly providers can get to the patient and intervene with high-quality CPR and defibrillation.\(^{31}\)

Given the overall prevalence of out-of-hospital cardiac arrest and its time sensitivity, the extent of resources applied to the treatment of these patients is substantial. As such, several investigators have attempted to identify which patients have no possibility of survival to hospital discharge by deriving and validating termination of resuscitation criteria for use in the out-of-hospital setting.\(^{11-20,32}\) Although several criteria have been proposed, the BLS and ALS termination of resuscitation criteria have been most extensively evaluated for use.\(^{15,17,19,20,32}\) These criteria, however, have not been evaluated specifically for use in predicting good neurologic survival.

A growing emphasis has been placed on good neurologic survival after out-of-hospital cardiac arrest because those individuals most likely to regain full, or near-full, neurologic capacities should be targeted for the most aggressive resuscitative efforts.\(^{18,33}\) Unfortunately, relatively little is known about how to identify patients who will survive with good neurologic outcomes. The neurologic termination of resuscitation criteria were specifically derived for this purpose.\(^{18}\) In that study, 3 clinical prediction rules were developed with classification and regression tree analysis to predict good neurologic survival (as defined by Glasgow Coma Scale scores of 13, 14, and 15), and the rule with the highest combined sensitivity and specificity was evaluated in this current study.

The most effective termination of resuscitation criteria should have a nearly perfect ability to predict good neurologic survival, thus minimizing termination of resuscitation of those patients who will survive out-of-hospital cardiac arrest neurologically intact. Also, the most effective termination of resuscitation criteria should have the ability to identify those patients who will not survive to hospital discharge or who will survive with poor neurologic function to minimize unnecessary aggressive resuscitation and transportation of patients. The 3 termination of resuscitation criteria evaluated in this study had similarly high abilities to predict good neurologic survival to hospital discharge. Each rule, however, had significantly different abilities to predict survival with poor neurologic function or no survival to hospital discharge, resulting in relatively different proportions of patients who would have received aggressive resuscitative efforts and transportation to a hospital but would not have survived neurologically intact. Of the 3, the BLS termination of resuscitation criteria had the highest combined predictive ability. In addition, the BLS termination of resuscitation criteria are the simplest (of the 3 criteria evaluated in this study) and are generalizable to both BLS and ALS EMS systems. Given its ability to predict poor neurologic survival or no survival to hospital discharge, the BLS termination of resuscitation criteria would have reduced transport of the highest number of patients without failing to identify any good neurologic survivors. These results compare favorably to previous studies that have attempted to evaluate the BLS termination of resuscitation and ALS termination of resuscitation criteria for the prediction of survival to hospital discharge (Table 5).

According to the National Association of EMS Physicians, delayed initiation of CPR (beyond 6 minutes), delayed initiation of defibrillation (beyond 8 minutes), failure to respond to at least 20 minutes of ALS, and patients who remain
in asystole or pulseless electrical activity are all factors that should be considered in establishing termination of resuscitation protocols. The authors of this position article suggest that this practice may reduce the demands and improve the safety of the broader health care system by limiting resuscitative efforts to those most likely to benefit. We believe this principle should be extended to only those patients who have a possibility of good neurologic survival.

Termination of resuscitation in the out-of-hospital setting would also reduce the growing demands on emergency personnel, allowing paramedics, physicians, and other emergency care providers to allocate more time to other patients who would likely benefit more from emergency medical care. In fact, in one study, resuscitative efforts in the ED were continued for an average of 33 minutes. In our cohort, applying the BLS termination of resuscitation criteria would have resulted in a time savings of approximately 127 hours of ED resuscitative efforts. As an example, if 5 medical personnel performed each resuscitation, this would translate into 635 person-hours saved. In addition, emergency transportation of patients who have no probability of good neurologic survival places paramedics, patients, and the general public at increased risk. The application of out-of-hospital termination of resuscitation criteria would reduce or eliminate this risk.

Medical personnel exhibit widespread variability in terminating resuscitation when not using specific termination of resuscitation criteria. Use of termination of resuscitation criteria would allow for a standardized approach to termination of resuscitation across populations. Surveys conducted on family members of patients who were pronounced dead in the field after failed resuscitative efforts indicate they are generally comfortable with these decisions.

In this external comparative validation study, all 3 termination of resuscitation criteria had equally high abilities to identify patients requiring continued resuscitation. The BLS termination of resuscitation criteria correctly identified the greatest number of patients who would have poor neurologic outcomes or death. Its relative simplicity and superiority in discriminating good neurologic survival support the use of the BLS termination of resuscitation criteria.

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Author contributions: MLR and JSH conceived and designed the study. JSH supervised data collection and management. JSH performed statistical analyses and all authors performed critical interpretation of the results. MLR drafted the manuscript and all authors contributed substantively to its revision. JSH takes responsibility for the article as a whole.

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REFERENCES


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