

Prehospital Termination of Resuscitation in Cases of Refractory Out-of-Hospital Cardiac Arrest

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CARDIAC ARREST IS PRIMARILY A fatal event. It is estimated that 166 200 out-of-hospital cardiac events occur each year in the United States, with approximately 60% of these events treated by emergency medical services (EMS).¹ Reported rates of survival following out-of-hospital cardiac arrest (OHCA) vary widely, from 0.2% (Detroit [2007])² to 23% (London, England [2005]).³ Nationwide, the median reported survival rate is 6.4%.⁴ The vast majority of patients who survive OHCA are resuscitated at the scene of the cardiac arrest and subsequently transported to the hospital for definitive care.^{5,6}

Nevertheless, the practice of EMS systems in cases of refractory OHCA vary widely from agency to agency. Although most systems generally follow the basic life support (BLS) and advanced life support (ALS) general resuscitation guidelines outlined by the American Heart Association,⁷ there is widespread variability in their application. In one study, adherence to American Heart Association

See also pp 1423 and 1462.

Context Identifying patients in the out-of-hospital setting who have no realistic hope of surviving an out-of-hospital cardiac arrest could enhance utilization of scarce health care resources.

Objective To validate 2 out-of-hospital termination-of-resuscitation rules developed by the Ontario Prehospital Life Support (OPALS) study group, one for use by responders providing basic life support (BLS) and the other for those providing advanced life support (ALS).

Design, Setting, and Patients Retrospective cohort study using surveillance data prospectively submitted by emergency medical systems and hospitals in 8 US cities to the Cardiac Arrest Registry to Enhance Survival (CARES) between October 1, 2005, and April 30, 2008. Case patients were 7235 adults with out-of-hospital cardiac arrest; of these, 5505 met inclusion criteria.

Main Outcome Measures Specificity and positive predictive value of each termination-of-resuscitation rule for identifying patients who likely will not survive to hospital discharge.

Results The overall rate of survival to hospital discharge was 7.1% (n=392). Of 2592 patients (47.1%) who met BLS criteria for termination of resuscitation efforts, only 5 (0.2%) patients survived to hospital discharge. Of 1192 patients (21.7%) who met ALS criteria, none survived to hospital discharge. The BLS rule had a specificity of 0.987 (95% confidence interval [CI], 0.970-0.996) and a positive predictive value of 0.998 (95% CI, 0.996-0.999) for predicting lack of survival. The ALS rule had a specificity of 1.000 (95% CI, 0.991-1.000) and positive predictive value of 1.000 (95% CI, 0.997-1.000) for predicting lack of survival.

Conclusion In this validation study, the BLS and ALS termination-of-resuscitation rules performed well in identifying patients with out-of-hospital cardiac arrest who have little or no chance of survival.

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guidelines for the out-of-hospital care of cardiac arrest was only 40%.⁸

During the past 30 years, several research teams have sought to define objective clinical criteria to identify patients who likely will not benefit from rapid transport to the hospital for further resuscitative efforts.⁹⁻¹⁸ Despite this research, many EMS systems still urgently transport patients with refractory cardiac arrest to the hospital for continued resuscitative efforts.¹⁹⁻²¹ Rapid transport with lights and siren

may pose hazards for EMS personnel and the public and should occur only when the risks of high-speed trans-

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port are justified by the potential benefits to the patient.²²

The Ontario Prehospital Advanced Life Support (OPALS) study group has proposed 2 termination-of-resuscitation rules for EMS personnel. Both rules were derived from the OPALS group's large registry of cardiac arrest cases. One rule is intended for use by responders providing BLS who are equipped with an automated external defibrillator.¹⁷ The other, more conservative rule, is intended for use by responders providing ALS.²³ A patient must meet all of the criteria included in either rule to warrant termination of resuscitation in the out-of-hospital setting.

The BLS rule has 3 criteria, whereas the ALS rule adds 2 additional criteria (BOX). The BLS rule was derived from an initial cohort of 662 patients¹⁷ and validated in a second cohort of 1240 patients.^{17,23,24} Of the 776 patients who met BLS criteria for termination of resuscitation efforts in the out-of-hospital setting, only 4 (0.5%) survived to hospital discharge. The researchers calculated that had the rule been in effect, nearly two-thirds of their patients with OHCA would have been pronounced dead in the out-of-hospital setting. High-speed EMS transports of patients with cardiac arrest would have decreased from 100% of cases to 37.4%.^{17,23,24}

The ALS rule was devised to reduce and ideally eliminate the small misclassification rate associated with the BLS rule and was derived from a cohort of 4673 patients.²³ Adding the 2 additional criteria—cardiac arrest not witnessed by a bystander and no bystander-administered cardiopulmonary resuscitation (CPR)—reduced the misclassification rate to zero. No patient who met all 5 ALS criteria survived to hospital discharge.²³ The authors estimated that had this rule been applied, approximately 30% of their patients with OHCA would have been pronounced dead in the out-of-hospital setting, and emergency transports of patients with cardiac arrest would have been reduced from 100% of cases to 70%. Unlike the BLS rule, the ALS rule has not been validated in a second co-

hort of patients with cardiac arrest. Despite their respective names, it is important to note that either rule can be applied by ALS personnel or by BLS personnel equipped with an automated external defibrillator.

To independently assess the validity of the BLS and ALS rules for identifying individuals with refractory OHCA who likely will not benefit from rapid transport to a hospital for further attempts at resuscitation, we performed a retrospective cohort study based on data from a large, preexisting surveillance registry of 7235 cases of OHCA drawn from 8 US cities.

METHODS

The data used in this analysis were obtained from the Cardiac Arrest Registry to Enhance Survival (CARES). This registry is designed to help local officials determine how well their community is performing in each link of the American Heart Association "chain of survival." Detailed information about this registry is published elsewhere.²⁵

From October 1, 2005, to April 30, 2008, 8 cities submitted data to CARES: Anchorage, Alaska; metropolitan Atlanta, Georgia; Boston, Massachusetts; Raleigh, North Carolina; Cincinnati, Ohio; Columbus, Ohio; Austin, Texas; and Houston, Texas. Because metropolitan Atlanta was the first community to report data, a plurality (50.5%) of the cases in this analysis are from Georgia. Percentages of cases in the other states submitting data were 32.1% (Texas), 7.4% (Ohio), 4.8% (North Carolina), 3.1% (Massachusetts), and 2.1% (Alaska). The registry is designed to capture all cardiac arrest events in a defined geographic area (city or county) for which the 911 system was activated. Data analysts confirmed the capture of all cardiac arrest events at each city's 911 center monthly during the data review process.

All cases submitted to the registry during the study interval were eligible for inclusion. A cardiac arrest case was excluded if (1) EMS personnel determined that arrest was due to a noncardiac etiology (eg, trauma, electrocu-

Box. Basic Life Support and Advanced Life Support Termination-of-Resuscitation Rules

Basic Life Support

Event not witnessed by emergency medical services personnel

No automated external defibrillator used or manual shock applied in out-of-hospital setting

No return of spontaneous circulation in out-of-hospital setting

Advanced Life Support

Event not witnessed by emergency medical services personnel

No automated external defibrillator used or manual shock applied in out-of-hospital setting

No return of spontaneous circulation in out-of-hospital setting

Arrest not witnessed by bystander

No bystander-administered cardiopulmonary resuscitation

tion, drowning, or respiratory); (2) out-of-hospital resuscitation was not attempted based on local EMS protocols (eg, obvious signs of death such as rigor mortis, decomposition, lividity); or (3) the patient was younger than 16 years.

Data Collection and Processing

Eight US cities prospectively submitted data in accordance with the CARES user agreement. The registry collects and links a limited standard set of data elements from 3 sources: 911 call centers, EMS personnel, and receiving hospitals. It is designed to provide EMS system managers with a simple and standard way to identify cases of OHCA, measure key response-time intervals, document the delivery of important interventions, and ascertain outcomes. The registry uses a secure, Health Insurance Portability and Accountability Act-compliant Web site so that hospitals can report each patient's outcome, length of stay, and cerebral performance category (CPC) score at the time

of hospital discharge; the registry also complies with the Utstein criteria for cardiac arrest reporting.²⁶

All submitted reports are reviewed by a data analyst. Once essential data elements pass this quality check, individual identifiers are stripped from the record and the case is permanently entered into the registry database. Once individual identifiers are removed, a case can be distinguished only on the basis of demographics (age, sex, and race/ethnicity) and the location of the event. Race/ethnicity is determined by the patient, family, or EMS personnel. This information was collected to better characterize any potential disparities that may exist in rates of bystander-administered CPR, location and types of arrest, or survival to hospital discharge.

A data set containing all events submitted to the registry database between October 1, 2005, and April 30, 2008, was secured from the Sansio Corporation server, which hosts the database. The data set was provided in Excel (Microsoft, Redmond, Washington) and subsequently transferred to Stata version 10.0 (StataCorp, College Station, Texas) for statistical analysis.

Data Analysis

The main outcome measures were the specificity and positive predictive value of the BLS rule and the ALS rule for identifying patients with OHCA who likely would not survive to hospital discharge. We estimated the potential effect each rule would have on rates of out-of-hospital pronouncement of death and EMS transports if the rule had been implemented.

Descriptive statistics of the baseline population, including counts, means, and standard deviations, were calculated. The data set was used to calculate the sensitivity, specificity, positive predictive value, and negative predictive value of the BLS and ALS rules for identifying patients who likely will not survive to hospital discharge.

Consistent with previous studies,^{17,24,27} we considered a misclassification rate of less than 1% as an acceptable criterion for a termination-of-resuscitation rule. Our

sample size of 1192 for the ALS rule provided more than 80% power (1-sided $\alpha = .05$) to detect a misclassification rate significantly lower than 1%; our sample size of 2592 for the BLS rule provided more than 90% power to detect that rate.

To determine the diagnostic accuracy of a decision rule, it must be compared against a gold standard. The gold standard in this study was survival to hospital discharge, as documented in hospital records. A sensitivity analysis was performed to exclude those patients not transported to the emergency department and for whom resuscitation efforts were terminated in the out-of-hospital setting as well as those patients whose clinical outcomes could not be determined.

Human Research Considerations

The CARES database is a continuous quality-improvement tool and surveillance registry providing deidentified data to help local officials monitor and improve their provision of out-of-hospital emergency cardiac care. Every patient received the standard care available in his or her community, and no patient received an experimental intervention. In light of these safeguards, the institutional review boards of all participating sites approved this study and determined that this registry was exempt from the requirement to secure oral or written consent.²⁸

RESULTS

Main Study Results

The full registry included 7235 cases collected from 19 EMS agencies and 111 hospitals located in 8 US cities. Of the 7235 cases, 406 were excluded because resuscitation was not attempted by paramedics, 1150 because the arrest was due to a noncardiac etiology, and 123 because the patients were younger than 16 years; an additional 51 were excluded because data documenting clinical outcome were missing. Therefore, a total of 5505 cardiac arrest cases met criteria for inclusion in the study. The overall rate of survival to hospital discharge of the remaining cases was 7.1% ($n=392$). A total of 947 (17.2%) were pronounced

dead in the out-of-hospital setting, based on local EMS agency protocols. TABLE 1 displays the demographic, clinical, and EMS characteristics for the study sample.

The FIGURE summarizes the performance of the BLS and ALS termination-of-resuscitation rules in our study sample. The BLS rule would have recommended out-of-hospital termination of resuscitation in 2592 patients (47.1%). Seventy patients who met BLS criteria for termination of care in the out-of-hospital setting were resuscitated in the emergency department and admitted to the hospital, and 5 (0.2%) who met BLS criteria survived to hospital discharge. Four of these patients were documented as having a good CPC score (score of 1 on a scale of 1-5, where 1 = good cerebral performance [conscious, alert, able to work and lead a normal life]; 2 = moderate cerebral disability [conscious and able to function independently—dress, travel, prepare food—but may have hemiplegia, seizures, or permanent memory or mental changes]; 3 = severe cerebral disability [conscious, dependent on others for daily support, functions only in an institution or at home with exceptional family support]; 4 = coma or vegetative state; and 5 = death) at the time of hospital discharge, and 1 had severe disability (CPC score of 3). If the BLS rule had been applied, EMS personnel would have terminated out-of-hospital resuscitation efforts in 1645 additional cases, increasing their rate of out-of-hospital pronouncement of death from 17% to 47%.

The more conservative ALS rule would have recommended out-of-hospital termination of resuscitation in 1192 cases (21.7%). Twenty-four of the patients who met ALS criteria for termination of care in the out-of-hospital setting were resuscitated in the emergency department, but none survived to hospital discharge. If the ALS rule been applied, EMS personnel would have terminated resuscitative efforts in 245 additional cases, increasing the rate of out-of-hospital pronouncement of death from 17% to 22%.

The BLS and ALS rules were both highly specific and had high positive

predictive values (TABLE 2). A positive diagnostic result was considered to be fulfillment of all 3 BLS or all 5 ALS criteria. The rules performed well in predicting which patients would benefit from further efforts at resuscitation (specificity) and which would not (positive predictive value). In our study, the BLS rule misclassified 0.2% of cases; the ALS rule misclassified no cases.

Sensitivity Analyses

In our study, 947 patients had resuscitation efforts terminated in the out-of-hospital setting based on local protocols. Of these patients, 144 (15%) did not meet 1 or more BLS criteria and 564 (59%) did not meet 1 or more ALS criteria. Excluding these 947 patients would not appreciably alter our results. The positive predictive value for the BLS rule would change from 0.998 (95% confidence interval [CI], 0.996-0.999) to 0.997 (95% CI, 0.993-0.999). The positive predictive value for the ALS rule would change from 1.000 (95% CI, 0.997-1.000) to 1.000 (95% CI, 0.995-1.000).

Fifty-one patients who otherwise met inclusion criteria (0.2%) were lost to follow-up. Eighteen of these 51 patients would have met BLS rule criteria, and 9 would have met ALS rule criteria. If all of these patients had survived, the BLS rule would have misclassified a total of 23 patients (0.4%), and the ALS rule would have misclassified 9 (0.2%). However, under the assumption that the survival rate in these patients was similar to that of the overall study sample (ie, 7.1%), inclusion of these patients would not appreciably alter our findings.

COMMENT

We sought to assess the usefulness of the BLS and ALS termination-of-resuscitation rules using data collected in 8 cities across the United States. We determined that both rules accurately identified patients with OHCA who were unlikely to benefit from rapid transport to the hospital for further attempts at resuscitation. Had either rule been used to guide decisions to cease resuscitative efforts in the out-of-hospital setting, EMS

systems could have substantially reduced the rate of emergency EMS transports without appreciably worsening the rate of cardiac arrest survival.

Given the choice, it is likely that many EMS medical directors and administrators would opt for the more conservative ALS rule, because that rule did not misclassify any survivors. However, adopting this rule would force some EMS systems to transport more patients than they currently do without ap-

preciably improving patients' odds of survival. Because receiving bystander-administered CPR warrants transport under the ALS rule, EMS systems that offer dispatcher-assisted CPR would have to transport nearly every patient.

The BLS rule misclassified 5 survivors in our study, resulting in a positive predictive value of 99.8%. If the rule had been consistently applied in the cities reporting to our registry, it would produce a higher rate of out-of-

Table 1. Characteristics of Patients With Out-of-Hospital Cardiac Arrest (N = 5505)

Characteristic	No. (%)
Age, mean (SD), y (n = 5470)	64.4 (16.4)
Men (n = 5504)	3286 (60.0)
Race (n = 5446)	
White	1940 (35.6)
Black	1542 (28.3)
Unknown	1435 (26.3)
Other	529 (9.8)
Location of arrest	
Home	3557 (64.6)
Nursing home/assisted living	797 (14.5)
Public building	350 (6.3)
Street/highway	251 (4.6)
Other	550 (10.0)
Type of initial rhythm (n = 5503)	
Ventricular fibrillation/ventricular tachycardia	1006 (18.3)
Unknown shockable rhythm	294 (5.3)
Unknown unshockable rhythm	715 (13.0)
Asystole	2486 (45.2)
Idioventricular/pulseless electrical activity	999 (18.2)
Other	3 (0.01)
Arrest witnessed by	
Bystander (n = 5501) ^a	2056 (37.4)
EMS/first responder (n = 5503) ^b	665 (12.1)
CPR attempted by (n = 5479)	
Bystander ^a	1123 (20.5)
Medical provider not part of EMS/first responder team ^{a,c}	677 (12.4)
Responding EMS personnel	3657 (66.7)
Other	22 (0.4)
Return of spontaneous circulation in out-of-hospital setting (n = 5503) ^b	1687 (30.7)
Pronounced dead in out-of-hospital setting	947 (17.2)
Survival	
To hospital admission	1208 (21.9)
To hospital discharge	392 (7.1)
Discharged with good CPC score ^d	190 (3.5)

Abbreviations: CPC, cerebral performance category; CPR, cardiopulmonary resuscitation; EMS, emergency medical services.

^aCriteria for advanced life support rule only.

^bCriteria for basic life support as well as advanced life support rules.

^cCardiac arrests in which CPR was initiated by medical personnel other than the EMS team/first responder were considered bystander-administered CPR in application of the termination-of-resuscitation criteria.

^dConsidered a score of 1 on a scale of 1-5, where 1 = good cerebral performance (conscious, alert, able to work and lead a normal life); 2 = moderate cerebral disability (conscious and able to function independently [dress, travel, prepare food] but may have hemiplegia, seizures, or permanent memory or mental changes); 3 = severe cerebral disability (conscious, dependent on others for daily support, functions only in an institution or at home with exceptional family support); 4 = coma or vegetative state; and 5 = death.

hospital pronouncement of death (47.1%) than the ALS rule (21.7%). However, use of either rule would increase out-of-hospital pronouncement rates above the aggregate rate of 17.2% currently reported by the cities participating in the registry.

In a recent assessment of the BLS rule, researchers from Arizona²⁹ reported that applying the rule to 2180 cases of adult nontraumatic cardiac arrest would have produced a rate of out-of-hospital pronouncement of death of 54%, with a misclassification rate of 0.09%. A single patient who met criteria for termination of resuscitation was misclassified; this patient eventually survived to hospital discharge and had moderate cerebral disability (CPC score of 2). These findings

are similar to our findings and to those of the OPALS study group.²⁴

National organizations such as the National Association of EMS Physicians and the American Heart Association have promoted guidelines that allow for termination of futile cardiac resuscitation efforts in the out-of-hospital setting. Both organizations recognize that rapid transport of patients who have little or no chance of survival poses risks and generates needless costs. However, reports published as recently as 2008 show that adherence to these guidelines is less than 50%.^{8,21,30} In a previous survey of EMS personnel, 40% of emergency medical technicians reported that they had provided resuscitation in situations in which they per-

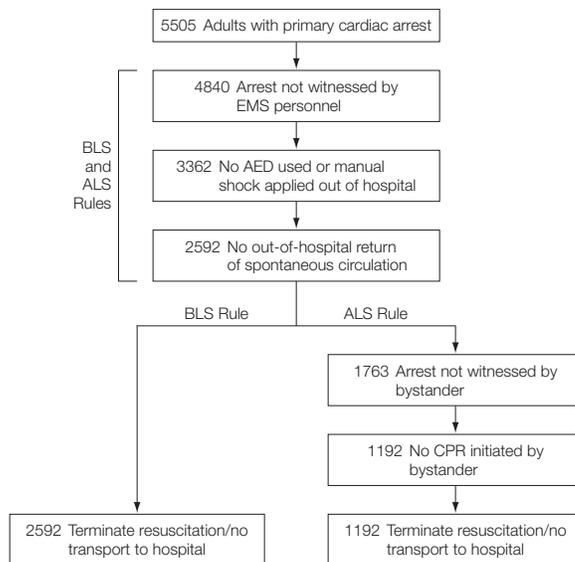
sonally would not have wanted anything done.³¹ In the same study, almost a quarter of all respondents stated that current guidelines for termination of resuscitation are inadequate.

Without specific, evidence-based guidance, many EMS personnel probably err on the side of caution by rapidly transporting patients with refractory OHCA to the hospital. However, rapid transport of patients with lights and siren, while EMS personnel are attempting cardiac resuscitation in the back of the moving vehicle, may pose risks to the personnel. In addition to the risk of injury from motor vehicle crashes or vehicle-pedestrian collisions, this practice may increase the risk of occupational exposure to contaminated blood and body secretions.³²

The decision to transport a patient with refractory cardiac arrest for additional efforts at the hospital entails substantial costs. These transports remove ambulance units from service for an extended period, limiting availability of EMS resources to other community members with treatable medical emergencies. Moreover, the arrival of a patient with cardiac arrest affects the workflow of the receiving emergency department, typically resulting in nurses, technicians, and physicians leaving the bedsides of other patients to engage in resuscitation efforts.³³ If the emergency department staff initially succeed at resuscitating the patient, in most cases it is still unlikely that the patient will survive and leave the hospital with good neurologic status.

Our study has several limitations. First, we used a multicommunity cardiac arrest registry in which case information was collected prospectively,

Figure. Estimated Potential Outcomes Associated With Application of Basic Life Support (BLS) vs Advanced Life Support (ALS) Rules and Rates of Out-of-Hospital Termination of Resuscitation



AED indicates automated external defibrillator; CPR, cardiopulmonary resuscitation; EMS, emergency medical services.

Table 2. Survival to Hospital Discharge Among Patients Meeting Criteria for the Basic Life Support (BLS) vs Advanced Life Support (ALS) Termination-of-Resuscitation Rules

	Died	Survived	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
BLS rule						
Met 3/3 criteria	2587	5	0.506 (0.492-0.520)	0.987 (0.970-0.996)	0.998 (0.996-0.999)	0.133 (0.121-0.146)
Did not meet criteria	2526	387				
ALS rule						
Met 5/5 criteria	1192	0	0.233 (0.222-0.245)	1.000 (0.991-1.000)	1.000 (0.997-1.000)	0.091 (0.083-0.100)
Did not meet criteria	3921	392				

Abbreviations: CI, confidence interval; NPV, negative predictive value; PPV, positive predictive value.

based on the Utstein criteria for standardized reporting of OHCA. However, because the CARES database decouples the data set from any individual identifiers, we were unable to access the original patient records to determine what factors, if any, contributed to the outcomes of the 5 patients (0.2%) who survived to hospital discharge despite meeting all 3 BLS criteria for termination of resuscitation. Nevertheless, with these cases included, the BLS rule had a positive predictive value of 99.8% for predicting lack of survival, which is within the acceptable range used by medical ethicists for defining futility.²⁷

Second, although our registry-based data set included cases from 8 different US cities, half of all cases were submitted by EMS systems operating in metropolitan Atlanta, Georgia. It is therefore possible that our findings might not be generalizable to other parts of the United States. However, the BLS and ALS termination-of-resuscitation rules both performed as well with our registry data set as they did with cases collected in Ontario and Arizona.

Third, neither the BLS rule nor the ALS rule consider patient age, the existence of comorbid or terminal conditions, collapse-to-treatment intervals, or the length of time a resuscitation effort is pursued before it is determined futile. These variables were filtered out in the statistical process that derived each rule. Research has shown that age alone is a weak predictor of survival.³⁴ Collapse-to-treatment intervals are important but are difficult for bystanders to estimate accurately.^{9,35,36} One guideline recommends 20 to 30 minutes of aggressive out-of-hospital advanced cardiac life support before attempting to transport a patient with OHCA.⁹ However, most other guidelines do not specify a time interval or the mandatory elements of an "adequate" resuscitation effort.

Once a clinical rule has been derived and validated, the next step is to assess its implementation. A prospective study is warranted to assess how well EMS systems implement either the

BLS rule or the ALS rule in clinical practice. To succeed, this will require the understanding and commitment of EMS personnel, system administrators, and EMS physicians, as well as the support of the community. Because adoption of either protocol will shift more pronouncements of death from the hospital to the out-of-hospital setting, including homes, it will be advisable for EMS researchers to evaluate the potential psychological and emotional ramifications of this practice on EMS personnel and bystanders, including family members of the deceased. EMS systems that routinely cease unsuccessful cardiac resuscitation efforts in the out-of-hospital setting reportedly have not encountered problems.^{37,38} Findings from 2 studies have shown that many family members are grateful to be spared the additional ordeal of following their loved one to the emergency department when it is obvious that the patient has already died.^{39,40} Educating the public about the appropriateness of out-of-hospital termination of futile resuscitation efforts may also help manage the community's sometimes unrealistic expectations about the probability of surviving OHCA.⁴¹ Moreover, EMS systems adopting a policy of out-of-hospital termination of resuscitation for the first time must ensure that certain logistical procedures are in place, such as the proper procedures to follow in pronouncing death and how EMS personnel will notify the police and mortuary services of the death.

Based on our findings and those of other research groups,^{23,24,29} we suggest that the BLS rule can be ethically applied by EMS systems in the United States. The BLS rule identified, with a high specificity and high positive predictive value, patients with OHCA who have a very low likelihood of survival to hospital discharge. Although some of these patients were resuscitated in the emergency department and spent several hours or days in the intensive care unit, only 5 (0.2%) identified by the BLS rule survived to hospital discharge.

The combined studies assessing these termination-of-resuscitation rules^{17,23,24,29}

included more than 10 000 patients. Application of the BLS rule would have increased rates of out-of-hospital pronouncement of death to an estimated nearly 50% in all 3 cohorts, with a 0.1% misclassification rate. Now that the BLS rule has been independently validated in multiple settings across both the United States and Canada, it may be time to consider standardizing the termination-of-resuscitation guidelines for OHCA. Widespread implementation of either rule could materially reduce the risk posed to EMS personnel during high-speed transports, decrease pressure on overburdened EMS systems, allow emergency department staff to focus on patients who have greater odds of survival, and decrease admissions to the intensive care unit of patients with out-of-hospital cardiac arrest who have little or no chance of surviving to discharge.

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