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Validation of a universal prehospital termination of resuscitation clinical prediction rule for advanced and basic life support providers☆

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ABSTRACT

Background: Prehospital termination of resuscitation rules have been derived for Emergency Medical Technician-Paramedics providing advanced life support care and defibrillation-only Emergency Medical Technicians providing basic life support care. We sought to externally validate each rule on a prospective cohort of prehospital cardiac arrest patients to determine if either rule could be proposed as a universal prehospital termination of resuscitation rule.
Methods: Investigators at the University of Toronto performed a secondary cohort analysis of data prospectively collected for the Resuscitation Outcomes Consortium Epistry-Cardiac Arrest trial from 1 April 2006 to 1 April 2007 by one site. The diagnostic test characteristics and predicted transportation rate were calculated for each rule.
Results: Of the 2415 patients with cardiac arrest of presumed cardiac etiology, the advanced life support rule recommended termination of resuscitation for 743 patients. No survivors were identified in this group. It had a specificity of 100% for recommending transport of potential survivors, a positive predictive value of 100% for death and a predicted transport rate of 69%. The basic life support rule recommended termination of resuscitation for 1302 patients, with no survivors. This rule had a specificity of 100%, a positive predictive value of 100% and a predicted transport rate of 46%.
Conclusions: Implementing the basic life support rule as a universal termination of resuscitation clinical prediction rule would result in a lower overall transport rate without missing any potential survivors. The universal rule would recommend termination of resuscitation when there was no return of spontaneous circulation prior to transport, no shock was given and the arrest was not witnessed by Emergency Medical Services personnel. This rule may be useful for emergency medical services systems with mixed levels of providers responding to cardiac arrest patients.

Introduction

Sudden cardiac arrest is a leading cause of death in North America,[1–3] with approximately 30,000 to 45,000 cases reported in Canada per year and the majority of these occur in the prehospital environment.[4] Despite recent improvements in advanced cardiac life support, the survival rates for out of hospital cardiac arrest remain quite low ranging from 4% to 9%.[2,5] Traditionally, these patients have been transported with ongoing resuscitative efforts to the closest emergency department.[6] However, there is a growing body of evidence to suggest that termination of resuscitation clinical prediction rules can be safely and logistically applied to a subset of prehospital cardiac arrest patients that are considered futile based on response to treatment provided by either paramedics[6–12] or defibrillation-only emergency medical technicians.[13–15]

In addition to the accumulating scientific evidence, national and international bodies such as the American Heart Association and the National Association of Emergency Medical Services Physicians have weighed in on this contentious topic by issuing their own guidelines for termination of resuscitation by paramedics in the prehospital environment.

In 2000, the National Association of Emergency Medical Services Physicians published a position statement on termination of resuscitation in adults with nontraumatic out of hospital car-

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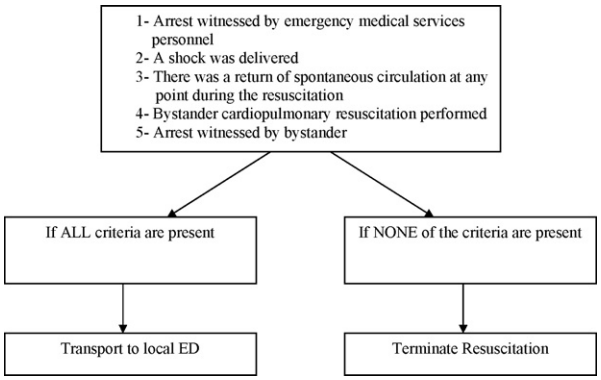

Figure 1. Advanced life support termination of resuscitation clinical prediction rule criteria: ED = Emergency Department.

diac arrest, stating that resuscitative efforts could be terminated in patients who do not respond to at least 20 min of advanced life support treatments such as cardiopulmonary resuscitation, definitive airway management, medication and defibrillation as needed.[6]

According to the 2005 American Heart Association guidelines, termination of resuscitation in the prehospital setting following system-specific criteria and under direct medical control should be standard practice in all Emergency Medical Services systems, as evidence confirms that ongoing advanced life support care in the Emergency Department offers no advantage over similar care in the field.[16] Variability in termination of resuscitation rates has been recorded when termination is left to the discretion of individual physicians providing medical control.[17] To address this variability, investigators from the University of Toronto derived an advanced life support clinical prediction rule through a secondary analysis of a study where adult cardiac arrest patients were treated by paramedics.[18] The rule predicted that prehospital cardiac arrest patients could be considered for termination of resuscitation by advanced life support paramedics if there was no return of spontaneous circulation at any point during resuscitation, no shock was given, the arrest was not witnessed by Emergency Medical Services personnel or bystanders and no bystander cardiopulmonary resuscitation was delivered (Fig. 1).

Investigators from the University of Toronto also derived and validated a basic life support termination of resuscitation clinical prediction rule addressing the lack of prospective data and treatment guidelines on this subject in the current literature.[15,19] Patients treated solely by defibrillation-only emergency medical technicians could be considered for termination of resuscitation if there was no return of spontaneous circulation prior to transport, no shock was given and the arrest was not witnessed by Emergency Medical Services personnel (Fig. 2).

Ideally, a single universal termination of resuscitation rule that could be employed by all levels of Emergency Medical Services providers should be developed to optimize consistency in practice across EMS services. Therefore, we sought to conduct an external validation of each rule on an identical prehospital patient cohort attended by both levels of providers. Diagnostic test characteristics and the transport rate for both the advanced life support termination of resuscitation and the basic life support termination of resuscitation clinical prediction rules were measured and compared with the aim of determining which rule, if either, could be recommended as a universal termination of resuscitation rule.

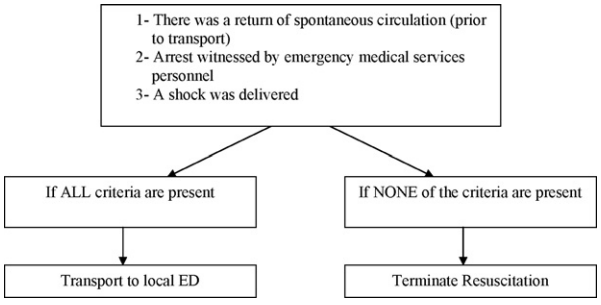

Figure 2. Basic life support termination of resuscitation clinical prediction rule. Criteria: ED = Emergency Department.

Methods

Study design

This investigation is an external validation of each rule retrospectively applied to data originally collected by the University of Toronto for the Resuscitation Outcomes Consortium Epistry – Cardiac Arrest trial; a population based registry of all out of hospital cardiac arrests.[20] The University of Toronto center is comprised of the Emergency Medical Services Systems within the city of Toronto and 5 adjacent municipalities (Peel, Durham, Hamilton, Muskoka and Simcoe) and the province-wide air ambulance service; Ornge (formerly Ontario Air Ambulance Corporation). These Emergency Medical Services systems serve a population of 6.7 million by land and 11 million by air.

Trained data guardians at each participating site abstracted cardiac arrest characteristics as well as patient demographics and final outcomes directly from source documents. The outcome of each prehospital cardiac arrest: pronounced dead on scene, pronounced dead after transport, or survived to hospital discharge was determined by chart review. All sites received approval from their regional institutional ethics board.

Study population

The study population was made up of consecutively enrolled adult patients who were treated by either paramedics or defibrillation-only emergency medical technicians on both for an out-of-hospital arrest of presumed cardiac cause between 1 April 2006 and 1 April 2007.[20] Cases were excluded for the following reasons: (1) non-cardiac etiology,[20] including trauma; (2) obviously dead as defined by local legislation and not treated; (3) under the age of 18; (4) a 'Do Not Resuscitate' order was presented to the paramedics. Advanced and basic life support care was provided in accordance with the 2000 American Heart Association guidelines[21] initially and later modified to include the changes in the 2005 guidelines.[16] A 911 response in all regions was a tiered response involving Police, Fire, defibrillation-only emergency medical technicians and in some regions Advanced Life Support Paramedics were also part of this tiered response.

Outcome measures

The primary outcome measure was to determine if any patient survived to hospital discharge but had met either the advanced life support or basic life support termination of resuscitation criteria. The advanced life support rule suggests termination when there was no return of spontaneous circulation at any point during resuscitation, no shock was given, the arrest was not witnessed by Emergency Medical Services personnel or bystanders and no bystander cardiopulmonary resuscitation (Fig. 1). The basic life support rule suggests termination when all three criteria are present; there was no return of spontaneous circulation prior to transport, no shock was given and the arrest was not witnessed by Emergency Medical Services personnel (Fig. 2). Secondary outcomes included

Table 1
Characteristics of patients and selected features of cardiac arrests included in the study ($n = 2415$).

Characteristic	Value
Patients	
Age (years) – mean ± SD	69.4 ± 15.4
Age (years) – range (min-max)	18–104
Male sex, no. (%)	1520 (63.0)
Witnessed by bystander	913 (38)
Witnessed by emergency medical services personnel	221 (9)
Bystander cardiopulmonary resuscitation, no. (%)	670 (28)
Defibrillated by emergency medical services	733 (30)
Prediction rule variables, no. (%)	
No return of spontaneous circulation	1953 (81)
No shock advised	1682 (70)
Not witnessed by emergency medical services personnel	2194 (91)
Not bystander witnessed	1502 (62)
No bystander cardiopulmonary resuscitation	1745 (72)

measuring the diagnostic test characteristics of both clinical prediction rules on the entire patient cohort as well as their respective transport rates.

The test characteristics included sensitivity, specificity, and positive and negative predictive values. An ideal test would not recommend the termination of resuscitation efforts if the patient could potentially survive cardiac arrest. Thus, the specificity of the rule (the probability that the rule recommended transport when the patient survived) and its positive predictive value (the probability of death when the rule recommended termination of resuscitative efforts) were identified as the key test characteristics.

The survival rate among patients for whom the prediction rule recommended the termination of resuscitation was also determined. Transportation rates were calculated based on the number of patients who would be recommended for transport to the ED by each clinical prediction rule.

The comparison of the rule's performance pre and post implementation of the 2005 American Heart Association guidelines[1] was defined a priori as a subgroup evaluation.

Statistical analysis

Descriptive statistics were calculated for all variables of interest. Continuous measures such as age were summarized using means and standard deviations, whereas categorical measures were summarized using counts and percentages. Diagnostic test characteristics (sensitivity, specificity, positive and negative predictive values) were reported along with their 95% confidence intervals. The statistical analysis was performed with SAS software version 8.0 (SAS Institute, Cary, NC, USA).

Results

From 1 April 2006 to 1 April 2007, a total of 4854 cases of out of hospital cardiac arrest occurred in our catchment area. Of this total, 2439 were excluded where 472 cases were deaths due to obvious cause; 259 cases recorded 'Do Not Resuscitate' advance directives, 1553 cases were obviously dead as defined by legislation and 155 cases were less than 18 years of age. The remaining 2415 cardiac arrest patients attended to by paramedics ($n = 1992$; 82.5%) or defibrillation-only emergency medical technicians ($n = 423$; 17.5%) were used in the analysis. Table 1 shows the demographic characteristics of the 2415 patients and routine covariates pertaining to out of hospital cardiac arrest.

Follow-up data was obtained on 99% of all patients who were enrolled in the study; out of 2415, only 19 (0.78%) had missing or irretrievable final outcomes. The majority of patients died (2266; 93.8%). Most died on scene (1069 cases; 44.3%); 4 cases died en route to the ED (0.16%), 924 cases (38.2%) were pronounced in the ED and 267 cases (11.0%) died after admission. Overall, 130 cases (5.4%) survived to discharge.

The actions according to the advanced life support and basic life support termination of resuscitation clinical prediction rules as well as their individual diagnostic test characteristics and predicted transport rates are shown in Tables 2 and 3, respectively. Both rules identified the 130 survivors, resulting in specificities of 100% (95% CI, 99.8–100%). The positive predictive values or the ability of the advanced life support and basic life support clinical prediction rules to predict death when termination of resuscitation is recommended was 100% (95% CI, 99.8 to 100%). However, the advanced life support rule resulted in a higher transport rate (69% vs. 46%) and lower sensitivity (33% vs. 57%).

Out of the 2415 enrolled cases, only one case that met the criteria for advanced life support termination of resuscitation in the field, achieved return of spontaneous circulation after leaving the scene and prior to arriving in the Emergency Department. Despite achieving return of spontaneous circulation, this patient was pronounced dead in the Emergency Department. Additionally there were two cases that met the criteria for basic life support termination of resuscitation, yet were transported to hospital with ongoing resuscitation whose final outcomes were irretrievable. Neither of these cases achieved return of spontaneous circulation during transport.

We tested the diagnostic test characteristics of both clinical prediction rules on the patient cohort ($n = 1231$) treated by all levels of providers after implementation of the 2005 American Heart Association guidelines[1] and found very similar results; the calculated specificity and positive predictive values were both 100% without missing any additional survivors (data not shown).

The transportation rates for both rules differed greatly. For the advanced life support termination of resuscitation rule, the transportation rate increased to 76% and for the basic life support termination of resuscitation rule the rate increased to 51%.

Limitations

As expected, the sensitivity is low for both the advanced life support termination of resuscitation clinical prediction rule (32.8; 95%

Table 2
Action according to advanced life support termination of resuscitation prediction rule* outcome.

	Death	Survival^	Total number of cardiac arrests
Terminate (test positive)	743	0	743
Transport to Emergency Department (test negative)	1523	130	1653
Total	2266	130	2396
Sensitivity (95% CI)		32.8 (30.8–34.7)	
Specificity (95% CI)		100 (99.8–100)	
Positive predictive value (95% CI)		100 (99.8–100)	
Negative predictive value (95% CI)		7.9 (6.8–9.0)	
Transport rate (%)		69.0	

* See Fig. 1 for criteria. ^Survival to hospital discharge.

Table 3
Action according to basic life support termination of resuscitation prediction rule* outcome.

	Death	Survival^	Total number of cardiac arrests
Terminate (test positive)	1302	0	1302
Transport to Emergency Department (test negative)	964	130	10944
Total	2266	130	2396
Sensitivity (95% CI)		57.5 (55.4–59.4)	
Specificity (95% CI)		100 (99.8–100)	
Positive predictive value (95% CI)		100 (99.8–100)	
Negative predictive value (95% CI)		11.9 (10.6–13.3)	
Transport rate (%)		45.6	

* See Fig. 1 for criteria. ^urvival to hospital discharge.

CI 32.6–33.0) and the basic life support termination of resuscitation clinical prediction rule (57.5%; 95% CI 57.3–57.7). Our analytical approach to determining diagnostic test criteria for termination of resuscitation clinical prediction rules was focused on identifying the individuals in the prehospital setting that will not benefit from further resuscitation (high specificity and positive predictive value) rather than identifying survivors. There has been inconsistency in how the diagnostic test criteria is reported for termination of resuscitation clinical decision rules and our results may not be comparable across some of the published literature where the diagnostic test characteristics of termination of resuscitation rules were focused on identifying survivors (sensitivity and negative predictive value).[20]

This study provides a retrospective validation of both rules in a large cohort of cases. A prospective validation of the basic life support rule suggested similar diagnostic test characteristics, provider compliance and comfort with applying the rule.[19,22] The advanced life support rule has not been prospectively validated and one could argue that it may perform differently during real time implementation.[18] We suggest that this is unlikely. Advanced life support paramedics have been terminating resuscitation efforts for years under the direct oversight of medical direction or by protocol. They also are more accustomed to following medical directives or protocols for drugs and devices. It may be reasonable to assume that advanced life support paramedics may adopt a medical directive pertaining to termination of resuscitation with similar comfort and adherence to protocol as was observed with defibrillation-only emergency medical technicians.[22]

Discussion

Both rules achieved high specificity and high positive predictive value when applied to a patient cohort attended by either paramedics or defibrillation-only emergency medical technicians or both. Our findings support using the basic life support termination of resuscitation rule as a universal clinical prediction rule in emergency medical services systems employing providers with either or both levels of certification. We suggest that implementation of this rule would result in a lower overall transport rate without missing any potential survivors and this was sustained during the application of the 2000 and 2005 American Heart Association resuscitation guidelines.

A universal termination of resuscitation rule would help to minimize practice variation among physicians providing online medical control in terminating resuscitative efforts for out of hospital cardiac arrest patients. Eckstein et al. demonstrated significant variability in physician decision to terminate resuscitation of out of hospital cardiac arrest patients in Los Angeles[17] where rates of termination of resuscitation varied from 5% to 37% depending on which physician took the call. A universal termination of resuscitation clinical decision rule with clear criteria for terminating resuscitation in the field would assist physicians in the decision making process and improve accuracy and reliability of application. Ultimately, a universal termination of resuscitation rule would ensure that withdrawal of care is consistently applied across all regions.

It is possible that the degree of variability in termination of resuscitation rates amongst physicians providing on line medical decision making demonstrated in the Eckstein study undermines paramedic comfort with the process of terminating resuscitation in the field. Indeed, a sub-analysis of the basic life support termination of resuscitation prospective validation study measuring the accuracy and comfort level of defibrillation-only emergency medical technicians who hypothetically applied the rule[22] showed that providers were able to accurately and reliably apply the basic life support rule and were generally comfortable with the application process. Their level of comfort with the process is important, as the burden of informing the family that resuscitation efforts have ceased and the patient is dead, transfers to the emergency medical services provider, instead of the Emergency Department physician. A study by Schmidt[23] and another by Delbridge[24] suggests families are satisfied with paramedics breaking the bad news and providing comfort. Psychological comfort with termination should help paramedics continue to provide effective counseling to the family. A universal clinical prediction rule should minimize physician variability and provide comfort to either level of paramedics in knowing that the outcome would be consistent across all providers and physicians providing medical control.

Most emergency medical services employ medical directives or protocols to ensure the standardization of care and to minimize error. This is helpful as the out of hospital setting is chaotic at times. In addition, many systems have both levels of providers working together and responding in sequence as a tiered response to a critically ill patient. Adopting a universal termination of resuscitation rule makes sense to reduce confusion in an already challenging environment. This is particularly relevant when both levels of providers may respond to the same call. The diagnostic test characteristics suggest either the basic life support or the advanced life support rule would be helpful. The basic life support rule reduces the transport rate from 69% to 46%. This optimizes the service availability for the next call, reduces unnecessary transports to the Emergency Department without compromising the comfort of the paramedic, the grief reaction of the family or the care of the patient.

In an editorial, Gordon Ewy[25] suggested that the rule required re-evaluation when care was provided in accordance with the 2005 American Heart Association guidelines.[1] Our comparison of the diagnostic test characteristics pre and post 2005 guidelines suggests the application of the rule is independent of care guidelines. As the quality of care improves, the patients are more likely to receive a shock or have a return in spontaneous circulation making them ineligible for termination of resuscitation and increasing the number of patients transported who may respond to continued resuscitation. Preliminary evidence suggests that the basic life support termination of resuscitation rule may serve as a universal clinical prediction

rule for both levels of providers after implementation of the 2005 American Heart Association Guidelines.

Conclusion

We have conducted an external validation of two termination of resuscitation clinical prediction rules on a patient cohort attended by advanced life support paramedics and defibrillation-only emergency medical technicians, and found both rules to have high specificity and high positive predictive value for patients unlikely to benefit from further resuscitation. Transport rates and sensitivities varied greatly between the two rules. Implementing the basic life support rule as a universal termination of resuscitation clinical prediction rule would result in a lower overall transport rate without missing any potential survivors. These findings may be useful for emergency medical services systems who wish to implement termination of resuscitation protocols for prehospital cardiac arrest patients attended by either level of provider or both in a tiered response system and would result in a significant reduction in the transport rate of patients without missing any potential survivors.

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Conflict of interest statement

None to declare.

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