Survival from prehospital cardiac arrest is critically dependent upon response time

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Summary

Study objective: This study correlated the delay in initiation of bystander cardiopulmonary resuscitation (ByCPR), basic (BLS) or advanced cardiac (ACLS) life support, and transport time (TT) to survival from prehospital cardiac arrest. This was a secondary endpoint in a study primarily evaluating the effect of bicarbonate on survival.

Design: Prospective multicenter trial.

Setting: Patients treated by urban, suburban, and rural emergency medical services (EMS) services.

Patients: Eight hundred and seventy-four prehospital cardiac arrest patients.

Interventions: This group underwent conventional ACLS intervention followed by empiric early administration of sodium bicarbonate noting resuscitation times. Survival was measured as the presence of vital signs on emergency department (ED) arrival. Data analysis utilized Student's t-test and logistic regression (p < 0.05).

Results: Survival was improved with decreased time to BLS (5.52 min versus 6.81 min, p = 0.047) and ACLS (7.29 min versus 9.49 min, p = 0.002) intervention, as well as difference in time to return of spontaneous circulation (ROSC). The upper limit time interval after which no patient survived was 30 min for ACLS time, and 90 min for transport time. There was no overall difference in survival except at longer arrest times when considering the primary study intervention bicarbonate administration.

Conclusion: Delay to the initiation of BLS and ACLS intervention influenced outcome from prehospital cardiac arrest negatively. There were no survivors after prolonged delay in initiation of ACLS of 30 min or greater or total resuscitation and transport time of 90 min. This result was not influenced by giving bicarbonate, the primary study intervention, except at longer arrest times.

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Introduction

The use of prehospital health care providers to intervene in acute cardiac emergencies has historically been a focus of emergency care. Eisenberg et al. reported the results of an evaluation of prehospital care by emergency medical technicians (EMT) compared to that delivered after the addition of paramedic skills, such as defibrillation, tracheal intubation and drug administration. They reported an improved rate of survival to the coronary care unit (CCU) (19–34%) and rate of hospital discharge (7–17%), which they related to a decrease in delay to advanced care delivery which was decreased to one-third from 27.5 to 7.7 min.

However, Dean et al. reported on the outcome of 134 patients who received mobile paramedic unit care compared to control patients without paramedic intervention demonstrating no change in outcome by multiple logistic regression analysis. Defibrillation was the only beneficial intervention identified, but also added a 29 min delay to hospital arrival suggesting the need for more streamlined care.

Later, Shuster and Chong went on to evaluate 15 prehospital studies over the early years of emergency medical care suggesting no benefit of prehospital administration of any of a number of common prehospital medications. Qualitatively, there have been few studies that have examined the use of such agents as albuterol, bicarbonate, bronchodilator agents, diazepam, dobutamine, dopamine, glucose, isoproterenol, naloxone, or nitrous oxide for their prehospital efficacy.

There are four factors that are related to the ability to resuscitate patients in the prehospital arrest setting. They include decreasing the time to starting rescue procedures, use of electrical defibrillation, accuracy of technique of basic life support (BLS), and ventilation efficacy.

The “early defibrillation” controversy has once again raised interest in use of first responders or EMT in a two-tier response system. Wilson et al. evaluated 126 patients whose care was limited to BLS: mask oxygen, IV fluids, external chest compressions, and artificial respiration. The survival rate was 22% (28) to hospital admission and 9% (11) to hospital discharge, with a favorable prognosis identified to include an initial rhythm of ventricular fibrillation or tachycardia, 14% (7 of 50); initial blood pressure >90 mmHg and pulse rate >50 bpm, 50% (3 of 6). However, if the patient was in cardiac arrest then cardiopulmonary resuscitation (CPR) did not change outcome.

Thus, the issue becomes a question of whether resuscitation endpoint can be determined past which no patient survives.

Methods

This prospective, randomized multicenter clinical trial involved cardiac arrest patients encountered by EMT-Ps in a prehospital setting, and transported to hospitals within the study area, usually within a 5–30 min radius. Patients were randomized individually to a treatment group receiving an empiric dose of bicarbonate (Abbott, USA) 1 ampule (50 mEq/L) early in the arrest cycle (Figure 1).

The demographics and clinical variables related to outcome were analyzed including, response to bicarbonate administration, scene factors, response time, cardiopulmonary variables, procedures, and duration of arrest. Patient outcome was recorded as the return of spontaneous circulation measured as palpable pulses and initial emergency department survival (discharge), as a primary endpoint.

Specifically, resuscitation intervention times were recorded as a secondary endpoint by the paramedic as estimated time of arrest (arrest time, AT), time until institution of bystander CPR (ByCPR), basic life support, advanced cardiac life support (ACLS), return of spontaneous circulation (ROSC) and scene to hospital transport time (TT) measured from arrest to hospital arrival time. In addition, ACLS intervention time is subcategorized into short-term (0–5 min), moderate (5–15 min), and long-term (>15 min) response for further analysis.

Examining these same issues according to the Office for Protection from Research Risk (OPRR) Guidelines suggest further qualification to waive prospective informed consent according to the second waiver condition of 45 CFR 46.116 section D. (1) The research involves no more than minimal risk to the subjects. (2) The waiver or alteration will not adversely affect the rights and welfare of the subjects. (3) The research practicably could not be carried out without the waiver or alteration. (4) Whenever appropriate, the subjects are provided with additional information after participation.

Numerical data were represented as means and standard deviation with Student's t-test, Fisher's exact, Chi square with Pearson correlation tests used for logistic regression intergroup comparison (alpha = 0.05) (SPSS/PC®+, Chicago, IL). The study results were examined by the investigators at 3-month intervals (or 25% of projected patients) to
verify early trends and outcome with capability of later modification.

Results

There were no significant differences in baseline pre-experimental demographic or cardiopulmonary variables in groups who were randomized to receive bicarbonate or not.

Overall, 874 patients were enrolled with an average age of 67.6 ± 15 (3–101) years and weight of 89.6 ± 40.3 kg. The response time to cardiopulmonary intervention did not correlate to bicarbonate administration as expected with randomization. The cumulative survival rate was 13.9% (110 of 792) with 82 (9.4%) patients excluded for lack of complete information on documentation.

The mean time to resuscitative intervention was 2.08 ± 2.77 (0–21) min for ByCPR, 6.62 ± 5.73 (0–35) min for BLS, 9.08 ± 6.31 (0–40) min for ACLS, 24.96 ± 13.55 (0–98) min for ROSC, and 41.05 ± 11.68 (0–92) min for hospital transport time (Table 1). Survival improved with decreased time to BLS intervention (5.52 min versus 6.81 min, p = 0.047) and ACLS intervention (7.29 min versus 9.08 min, p = 0.002).

Table 1  Response time correlation to ER survival

<table>
<thead>
<tr>
<th>Time interval</th>
<th>Mean (min)</th>
<th>Range (min)</th>
<th>Survivors (min)</th>
<th>Non-survivors (min)</th>
<th>t-Test (p)</th>
</tr>
</thead>
</table>
| ByCPR  
N = 259 | 2.08 ± 2.77 | 0–21 | 1.58 ± 1.71 | 2.20 ± 2.79 | 0.07 |
| BLS  
N = 484 | 6.63 ± 5.73 | 0–35 | 5.52 ± 4.75 | 6.81 ± 5.66 | 0.047 |
| ACLS  
N = 618 | 9.08 ± 6.31 | 0–40 | 7.29 ± 5.76 | 9.49 ± 6.30 | 0.002 |
| ROSC  
N = 148 | 4.96 ± 13.55 | 0–98 | 27.27 ± 13.71 | 20.73 ± 12.82 | 0.006 |
| Hospital  
N = 533 | 41.05 ± 11.68 | 0–92 | 39.69 ± 12.91 | 41.65 ± 11.31 | 0.214 |
Table 2  ACLS resuscitation interval correlated to ER survival

<table>
<thead>
<tr>
<th>ACLS time (min)</th>
<th>Non-survival</th>
<th>Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–8</td>
<td>227 (80.2)</td>
<td>56 (19.8)</td>
</tr>
<tr>
<td>&lt;8</td>
<td>248 (88.6)</td>
<td>32 (11.4)</td>
</tr>
<tr>
<td></td>
<td>475 (84.4)</td>
<td>88 (15.6)</td>
</tr>
</tbody>
</table>

Values in parenthesis are in percentages. Chi square Pearson correction. \( p = 0.0063 \); \( p = \text{NS} \) bystander CPR (<2 min), BLS (<4 min).

9.49 min, \( p = 0.002 \), while the time to ByCPR only approached significance (1.58 min versus 2.20 min, \( p = 0.07 \) (Table 1).

For those patients who respond to intervention and survive, the time until ROSC was increased compared to those who have ROSC and then do not survive (27.27 min versus 20.73 min, \( p = 0.0006 \)). The time interval after which no patient was able to survive was 25 min for ACLS and 40 min for transport time.

A convenience grouping of resuscitation interval data suggest that previously established benchmarks for ByCPR (<2 min, \( p = 0.375 \)) and BLS (<4 min, \( p = 0.006 \)) are not associated with improved survival, while provision of ACLS (<8 min, \( p = 0.006 \)) is strongly correlated with improved survival (Table 2). \(^7\)

In fact, experimental classification of ACLS resuscitation interval finds a significant reduction in survival comparing short (24.0%) to moderate (12.7%) duration arrest with a 47% decrease in relative risk of mortality, while a less significant reduction was noted compared to long-term arrest (9.1%) with a 28% decrease in relative risk (Table 3). There was no overall difference in survival with bicarbonate administration unless there was prolonged (>15 min) resuscitation time.

Table 3  Time to ACLS correlated to ER survival

<table>
<thead>
<tr>
<th>ET ACLS</th>
<th>ER survival</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-survival</td>
</tr>
<tr>
<td>Short-term (0–5 min)</td>
<td>130 (76.0)</td>
</tr>
<tr>
<td>Moderate (5–15 min)</td>
<td>275 (87.3)</td>
</tr>
<tr>
<td>Long-term (&gt;15 min)</td>
<td>70 (90.9)</td>
</tr>
<tr>
<td></td>
<td>475 (84.4)</td>
</tr>
</tbody>
</table>

Values in parenthesis are in percentages. Chi square Pearson correction. \( p = 0.00112 \).

Discussion

Clearly, there is a wide discrepancy in the rates of survival in in-hospital compared to prehospital cardiac arrest events. Rosenberg et al. evaluated 300 hospitalized patients demonstrating a 54% initial post-CPR survival followed by 23% survival to hospital discharge. \(^9\) Predictors of good resuscitation outcome include initial ventricular tachycardia or fibrillation, and brief duration of cardiac arrest CPR <30 min.

Wright found response times of less than 4 min resulted in improved survival to discharge in 23.1 compared to 7.0% of VF/VT events, and 30.8 compared to 7.7% of other arrhythmic events. \(^10\) Likewise, the use of ByCPR improved outcome from 23.1 to 42.9% in VF/VT and 7.7 to 15.8% when ACLS providers arrived within 4 min. \(^10\)

Similar survey data from the study by Valenzuela et al. of 372 prehospital patients demonstrated a 20% survival rate to hospital admission and 6% survival to discharge. \(^11\) This rate improved to 26% for hospital admission and 10% for hospital discharge in witnessed events, and 38 and 15%, respectively, for witnessed ventricular fibrillation.

Van der Hoeven et al. conducted a retrospective chart review of 309 adult patients where the 13.6% survived to hospital discharge was associated with a favorable prognosis with the arrest being witnessed, short call response interval, initial cardiac rhythm of VF or VT, and the provision of appropriate ACLS care. \(^12\) Improvement of all aspects of the "prehospital chain of survival" is likely to result in better outcome.

Perhaps the most important consideration in outcome prediction in adult prehospital cardiac arrest is the time until definitive resuscitation intervention is begun. One such measure is scene time (ST) evaluated by Spaite et al. in 298 patients. \(^13\) Here, only a minority (27.0%) of patients had ST <12 min, but they were more likely to have ROSC (26.6% versus 15.9%) and were more likely to survive (13.9% versus 6.5%) compared to those on scene for more prolonged periods.

However, demographic analysis of prehospital arrests found deficiencies in documentation with reports filed on 89% with VF as the first recorded rhythm in 52% progressing to asystole or EMD in 86% yielding a 2% survival to hospital discharge. \(^5\) They reported a median time to BLS of 6 min, call to response time of 8 min, call to ALS time of 2 min, and ST of 15 min for EMT and 31 min for EMT-P.

Likewise, survival to hospital discharge has been clearly related to the interval until therapeutic intervention. The periods from collapse until initiation of BLS (3.6 min versus 6.1 min) and
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This delay allows time for adequate compressions to restore perfusion, accompanied by vasopressor use for acid-base correction. This concept has been embodied by the intubation-compression before defibrillation scenario for resuscitation. The conclusion that individuals are more likely to be resuscitated after brief delay seems self-evident. However, the greatest value of these data are directed toward establishing specific discriminators for non-survival so that we may improve the direction of our resuscitative efforts.

There is a significant improvement in survival noted as time to resuscitation is decreased, increasing survival two-fold in Pell's Scottish trial and three-fold in Blackwell's mid-Atlantic EMS study. Although convenience grouping data—ByCPR (<2 min), BLS (<4 min), ACLS (<8 min), and hospital transport (<40 min) are helpful as quality assurance markers they do not allow prediction of individual patient outcome. However, it is helpful to note that there appears to be a plateau effect where there is less than one-third variability in survival between moderate (5–15 min) and prolonged (>15 min) arrest.

The best estimate of the upper limit of survival in the prehospital setting is that there are no survivors of normothermic arrest beyond an ACLS time interval of 30 min and transport time of 90 min.

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References