The Influence of Urban, Suburban, or Rural Locale on Survival From Refractory Prehospital Cardiac Arrest

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There are many variables that can have an effect on survival in cardiopulmonary arrest. This study examined the effect of urban, suburban, or rural location on the outcome of prehospital cardiac arrest as a secondary end point in a study evaluating the effect of bicarbonate on survival. The proportion of survivors within a type of EMS provider system as well as response times were compared. This prospective, randomized, double-blind clinical intervention trial enrolled 874 prehospital cardiopulmonary arrest patients encountered by prehospital urban, suburban, and rural regional EMS area. Population density (patients per square mile) calculation allowed classification into urban (>2000/mi^2), suburban (>400/mi^2), and rural (0-399/mi^2) systems. This group underwent standard advanced cardiac life support (ACLS) intervention with or without early empiric administration of bicarbonate in a 1-mEq/kg dose. A group of demographic, diagnostic, and therapeutic variables were analyzed for their effect on survival. Times were measured from collapse until onset of medical intervention and survival measured as the presence of ED vital signs on arrival. Data analysis used chi-squared with Pearson correlation for survivorship and Student t test comparisons for response times. The overall survival rate was approximately 13.9% (110 of 793), ranging from 9% rural, 14% for suburban, and 23% for urban sites for 372 patients (*P* = .007). Survival differences were associated with classification of arrest locale in this sample-best for urban, suburban, followed by rural sites. There was no difference in time to bystander cardiopulmonary resuscitation, but medical response time (basic life support) was decreased for suburban or urban sites, and intervention (ACLS) and transport times were decreased for suburban sites alone. Although response times were differentiated by location, they were not necessarily predictive of survival. Factors other than response time such as patient population or resuscitation skill could influence survival from cardiac arrest occurring in diverse prehospital service areas. (Am J Emerg Med 2004;22:90-93. © 2004 Elsevier Inc. All rights reserved.)

Eisenburg reported the results of an evaluation of prehospital care by EMTs compared with that delivered after the addition of paramedic skills such as defibrillation, endotracheal intubation, and drug administration to the resuscitation armaterium.[7] They reported an improved rate of survival to the coronary care unit (CCU, 19-34%) and rate of hospital discharge from 7% to 17%, which they related to a decrease in time delay to advanced care delivery, which was decreased to one-third from 27.5 to 7.7 minutes.

They then went on to refine the analysis of 487 prehospital arrest patients cared for by EMT or paramedics (EMT-P) in specific areas with annual arrest incidence of 5.6 to 6.0 per 10,000 patients. Proportionally more lives were saved in EMT-P than EMT provider areas with 8.4% and 1.3% mortality reduction, respectively, a sixfold increase in survivorship.[1]

The use of prehospital healthcare providers to intervene in acute cardiac emergencies has historically been a focus of emergency care. However, Dean reported on the outcome of 134 patients who received mobile paramedic unit care compared with control patients without EMT-P intervention demonstrating no change in outcome by multiple logistic regression analysis.[2] Defibrillation was the only beneficial intervention identified, but also added a 29-minute delay to hospital arrival, suggesting the need for more streamlined care.

Later, Shuster went on to evaluate 15 prehospital studies during the early years of emergency medical care suggesting no benefit of prehospital administration of any of a number of commonly administered prehospital medications.[3] 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.[4]

Paramedic effectiveness has been described for advanced cardiac life support (ACLS) intervention with a 91.7% success rate of obtaining intravenous access and 91% for intubation; however, drug administration was only consistent with 43% of resuscitation recommendations by intravenous route and 37% by endotracheal route.[5] Stricter compliance with national ACLS guideline facilitation involving extended refresher training courses could improve effectiveness.

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

The "early defibrillation" controversy has once again raised interest in utilization of first responders or EMT in a two-tier response system. Wilson evaluated 126 patients whose care was limited to BLS: mask oxygen, intravenous fluids, closed chest massage, and artificial respiration.[6] The survival rate was 22% (28) to hospital admission and 9% (11) to hospital discharge, with a favorable prognosis group identified to include those with initial rhythm of ventricular

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fibrillation or tachycardia 14% (7 of 50), and initial blood pressure >90 mm Hg and pulse rate >50 beats/min, 50% (3 of 6). However, if the patient was in cardiac arrest, then cardiopulmonary resuscitation did not change outcome.

METHODS

This prospective, randomized, multicenter clinical trial involved patients experiencing cardiac arrest encountered by EMT-Ps in a prehospital setting, who were administered bicarbonate or placebo and transported to hospitals within the study area, usually within a 5- to 30-minute transport radius. The multicenter trial enrolled patients encountered by Western Pennsylvania EMS systems into this protocol.

Inclusion criteria were subjects experiencing cardiac arrest refractory to defibrillation in whom intravenous access was obtained from 1992 to 1996. Exclusion criteria included those subjects experiencing from overt respiratory or traumatic arrest, children <18 years of age, and those without intravenous access. Patients received standard ACLS protocol, including chest compressions, ventilation, defibrillation, epinephrine (0.01 mg/kg), atropine (0.01 mg/kg), and antiarrhythmics or pressor agents as warranted. Patients were individually randomized to a treatment group receiving an empiric dose of bicarbonate (1 (50-mEq/L ampule; Abbott, USA) early in the arrest cycle. The control group received an equal amount of normal saline in a double-blind fashion to clarify the benefits of the osmolar load versus base deficit correct treatment and placebo.

Routine demographic and clinical variables related to outcome were analyzed, including demographics, response to bicarbonate administration, scene factors, response time, cardiopulmonary variables, procedures, and duration of arrest.

Routine cardiopulmonary variables were monitored. Neurologic outcome was measured initially as the Glasgow Coma Score, whereas long-term outcome was assessed by the Folstein Mini Mental Exam postarrest.[7,8] Patient outcome was recorded as the return of spontaneous circulation (mean atrial pressure of 50 mm Hg) and initial ED survival (discharge) as a primary end point.

The EMS services were single-tier paramedic response with coverage areas stratified according to population density (patients per square mile of EMS coverage area) where urban areas included (>2000 patients/mi^2), suburban (>400/mi^2), and rural (<399/mi^2) sites. Survival was then correlated to treatment site, as well as analysis of resuscitation response times.

Specifically, resuscitation intervention times were recorded as a secondary end point by the EMT-P as estimated time of arrest (ET arrest), time until institution of bystander cardiopulmonary resuscitation (ET ByCPR), basic life support (ET BLS), advanced cardiac life support (ET ACLS), return of spontaneous circulation (ET ROSC), and scene to hospital transport time (ET TT), noting that out-of-hospital discharge is the desirable resuscitation end point. In addition, ACLS intervention time is subcategorized into short-

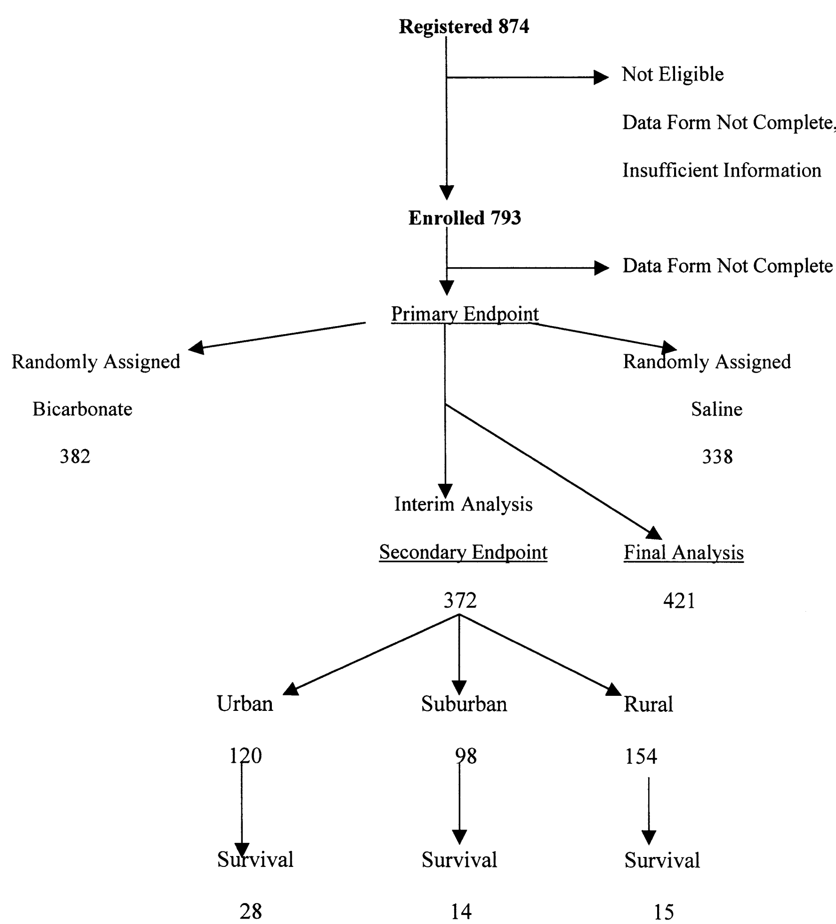

FIGURE 1. Trial profile.

TABLE 1. Survival Associated With Arrest Locale

Locale	Survival	Nonsurvival	Total
Urban	28	92	120
Suburban	14	84	98
Rural	15	139	154
	57	315	372

Chi-square $P = .0078$.

term (0-5 minutes), moderate (5-15 minute), and long-term (>15 minute) response for further analysis based on our animal model.

Patients were enrolled under the Doctrine of Implied Consent for the emergency use of an accepted resuscitation modality, and notification was provided if requested by family or healthcare resources. Their hospital records were not reviewed. In addition, administration of Food and Drug Administration-approved agent (sodium bicarbonate) in the emergency setting for moderate to prolonged arrest could be the standard of care, and in conjunction with the previously mentioned conditions that are met, consent could be waived. This study was approved by the University Institutional Review Board under this rationale in 1992 and was modified to address Office for Protection from Research Risk issues concerning "deferred consent."[9]

Numerical data was represented as means and standard deviation with Student 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

The overall survival rate was 15.3% (57 of 372) with a range finding the lowest survival rate of 9% (15 of 154) in rural, followed by 14% (14 of 98) for suburban, in comparison to 23% (57 of 372) for urban sites from the analysis from the interim analysis (Fig 1). There was a highly significant difference ($P = .007$) noted between urban and either suburban or rural sites (Table 1).

There was no difference in the time until provision of ByCPR (2.5-2.7 min, P = not significant) for the various sites. However, BLS care was provided more rapidly for urban and suburban than rural sites (5.1 ± 7.6 min, $P = .010$) (Table 2). The most rapid ACLS response occurred in suburban sites (6.9 ± 5.2 min), followed by urban response (8.7 ± 5.6 min), and finally rural sites (10.6 ± 7.3 min) ($P = .0002$). A similar trend was noted in hospital transport time with the shortest delay noted in suburban (37.1 min) locations followed by urban (39.1 min) with the most considerable delay found in rural sites (45.8 min, $P = .00005$).

DISCUSSION

The scope of the urban EMT-P practice has been well described, noting differences in practice of airway management, defibrillation, volume administration, medications, and medical command utilization.[10] Efficiency analysis finds that a limiting factor in resource utilization of a rural EMS is the availability and efficacy of EDs as opposed to critical care beds.[11]

Specifically, resuscitation intervention times were recorded over three million inhabitants, in which 91% of patients were pronounced dead in the ED and 7% died in hospital, leaving only 2% who survived to hospital discharge.[12] The PreHospital Arrest Survival Evaluation (PHASE) study evaluated 3243 consecutive cardiac arrest patients with an overall survival of 1.4% (99% confidence interval [CI], 0.9-2.3%) improving to 5.3% (99% CI, 2.9-8.8%) in witnessed cases.[13] However, this rate of survival was significantly lower than reported in midsized suburban/urban areas (33%; 99% CI, 3.4-35.6%; $P < .0001$) and suburban/rural areas (12.6%; 99% CI, 8.9-16.3%; $P < .001$). More moderate-sized sites (>100,000 + population) analyzed suggests from a 279 patient group a 4.0% overall and 5.8% witnessed arrest hospital discharge rate were observed.[14]

Therefore, there is wide-ranging variability in reported prehospital arrest survival rate, suggesting the need for standardization of arrest model, the population, and intervention provided to allow valid comparison between studies.

The overall survival rate of 13.9% (110 of 793) compares favorably to a 3.8% (1.7-13%) pooled analysis of 3220 prehospital patients.[15] Clearly, the rate of resuscitation (23%) was significantly higher in the urban site, almost a twofold improvement compared with the average survival (13.9%) for all sites.

On first analysis, it might seem that the result is directly proportional to the travel time and distance involved. However, one of the most significant predictive factors is the time to ACLS response, which could explain the difference for rural sites (10.6 min, 9% survival) but not suburban (6.9 min, 14% survival). Here, a paradoxical response was noted in which a 39% decrease in survival was noted compared with urban sites, even associated with a decreased time to ACLS care provision.

Response times were different based on location, but they were not necessarily predictive of survival. Although the

TABLE 2. Response Time (minutes) Compared With Arrest Location

	Overall	Urban	Suburban	Rural	Significance (P)
Bystander CPR	2.5 ± 3.11	2.5 ± 2.7	2.7 ± 4.0	2.5 ± 3.2	NS
BLS	6.3 ± 5.3	5.1 ± 4.2	5.1 ± 2.9	7.6 ± 6.4	.0109
ACLS	8.9 ± 6.3	8.7 ± 5.6	6.9 ± 5.2	10.6 ± 7.3	.0002
Transport time	41.0 ± 12.5	39.1 ± 11.1	37.1 ± 11.7	45.8 ± 12.8	.00005

Student's t test.
Abbreviations: CPR, cardiopulmonary resuscitation; BLS, basic life support; ACLS, advanced cardiac life support.

urban sites had a twofold improvement in outcome (23.3 vs. 14.3%), they did not necessarily have the shortest delay to ACLS provision, this factor is commonly associated with improved outcome, even though the BLS time was at least as rapid as that for the suburban locations.

Thus, it would seem that there was another factor other than response time responsible for this effect. Our study design did not address additional causative factors, so further analysis is purely conjecture. Issues and explanation that could be involved include differences in patient severity, premorbid condition, as well as prehospital paramedic or physician provider education and expertise. Interestingly, the urban hospital site is staffed using a resident physician rapid response system caring for the critically ill.

However, independent of the etiology, it appears that in this study sample that there was a highly significant twofold improvement in urban versus rural cardiac arrest outcome with a 30% improvement noted between suburban and rural sites. The time factor appears to be implicated when considering the rural site but does not explain the superior outcome in the urban population, because the time to ACLS care is less at suburban sites, probably based on lack of traffic and congestion delay.

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