

Cardiac Arrest Resuscitation Evaluation in Los Angeles: CARE-LA

Marc Eckstein, MD

Samuel J. Stratton, MD, MPH

Linda S. Chan, PhD

From the Departments of Emergency Medicine (Eckstein, Chan), Pediatrics (Chan), and Surgery (Chan), Keck School of Medicine of the University of Southern California, Los Angeles, CA; the Los Angeles Fire Department, Los Angeles, CA (Eckstein); the Department of Emergency Medicine, University of California–Irvine, Irvine, CA (Stratton); the Los Angeles County EMS Agency, Los Angeles, CA (Stratton); and the Los Angeles County–University of Southern California Medical Center, Los Angeles, CA (Eckstein, Chan).

Study objective: We determine survival for out-of-hospital cardiac arrests in Los Angeles using the Utstein method and compare these data with that reported for other urban and suburban areas.

Methods: This was a prospective observational cohort study of adult patients in Los Angeles presenting with nontraumatic, out-of-hospital cardiac arrest and with attempted out-of-hospital resuscitative efforts between July 1, 2000, and July 1, 2001. Entry criteria, time intervals, and nodal events conformed to Utstein template recommendations. The single target endpoint was neurologically intact survival at hospital discharge.

Results: Of 2,021 consecutive cardiac arrest patients on whom resuscitation was attempted, 1,700 (84%) met entry criteria as a primary cardiac event. Overall, neurologically intact survival was 1.4% (99% confidence interval [CI] 0.8% to 2.4%). Three patients were lost to follow-up. Survival from bystander-witnessed ventricular fibrillation was 6.1% (99% CI 3.3% to 11.0%). Absolute survival differences from witnessed ventricular fibrillation was higher but not statistically different than that from Chicago (−3%; 99% CI −8% to 2%) and New York City (−2%; 99% CI −6% to 3%). The rate of bystander cardiopulmonary resuscitation (CPR) for our population was 28%, for which the overall survival rate was 2.1%. The survival rate for patients with witnessed arrests and bystander CPR was 3.2%. Among patients with no bystander CPR, the survival rate was 1.0%.

Conclusion: Survival from out-of-hospital cardiac arrest in Los Angeles was low but similar to that reported for New York and Chicago. This low survival rate may be due to population density, low bystander CPR rates, and traffic congestion delaying emergency response. [Ann Emerg Med. 2005;45:504-509.]

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INTRODUCTION

Approximately 250,000 Americans die each year from sudden cardiac arrest, the overwhelming majority of which occurs outside of the hospital.¹ Despite years of research in resuscitation, there is a wide range of reported survival rates from out-of-hospital cardiac arrests.² Since publication of the Utstein template for reporting of survival rates from out-of-hospital cardiac arrest, reported survival rates for patients with witnessed cardiac arrest whose initial rhythm is ventricular fibrillation varies from 4% to 45%.³⁻⁸

Although survival from out-of-hospital cardiac arrest is a widely accepted benchmark of emergency medical services (EMS) performance, such data have been reported only in the standardized Utstein format from a few major US metropolitan areas.^{2,5-10} It is precisely these data that allow an EMS system to examine its performance and make changes to identify

and strengthen each link in the cardiac arrest “chain of survival.”¹¹

Since publication of the survival rates from Chicago in 1991⁷ and New York in 1994,⁵ the opportunity for early defibrillation has been improved in Los Angeles. As opposed to the EMS systems reported in the earlier New York and Chicago studies, every first-responder fire apparatus (engines and trucks) in this Los Angeles study was staffed by firefighters who are certified emergency medical technicians (EMTs) who carry an automated external defibrillator. These fire apparatuses are dispatched along with a paramedic ambulance on all EMS calls that are determined by the priority dispatch system to need advanced life support.¹²

In this study, there were more than twice as many first-responder fire apparatuses as there were paramedic ambulances deployed throughout Los Angeles. Because the fire apparatus

Editor's Capsule Summary

What is already known on this topic

Reports in the early to mid-1990s of patient outcomes after out-of-hospital cardiac arrest in very large metropolitan areas are poor, even with witnessed collapse and ventricular fibrillation observed on first rhythm assessment.

What question this study addressed

What are the outcomes of patients experiencing out-of-hospital cardiac arrest in Los Angeles during 12 consecutive months in 2000 to 2001? How do they compare with outcomes in other large cities?

What this study adds to our knowledge

Outcomes in Los Angeles are poor and similar to those reported from Chicago in 1991 and New York in 1994. Less than 2% of all arrests and just over 6% of patients with witnessed ventricular fibrillation arrest survive intact.

How this might change clinical practice

This study will not change clinical practice, but articles such as this may make public health and emergency medical services leaders seek novel strategies to try to improve outcomes.

typically arrives on scene before the arrival of the paramedic ambulance, it was anticipated that the decreased time until first shock might improve survival rates.⁴

In this article, we report the results of the Cardiac Arrest Resuscitation Evaluation in Los Angeles (CARE-LA) study, which was designed to determine the neurologically intact survival rates from out-of-hospital cardiac arrest in the city of Los Angeles. We discuss comparisons with similar data reported from other cities, with a focus on Chicago and New York, which, together with Los Angeles, comprise the 3 most populous cities in the United States.¹³

MATERIALS AND METHODS

Study Design

The city of Los Angeles encompasses 468 square miles with a resident population of 3,700,000.¹² EMS is provided by the Los Angeles Fire Department (LAFD). Of 2,500 firefighters, 2,000 are certified as EMT-defibrillator, and 500 are licensed paramedics. All 102 fire engine companies and 47 truck companies that respond to emergencies are equipped with an automated external defibrillator. Patients requiring advanced life support typically have a first-responder fire engine that arrives on scene first, followed by a paramedic ambulance. During the study period, LAFD used a constant staffing model, with 62 paramedic ambulances and all fire-suppression

(first-responder) companies on duty at all times throughout the city.

All 911 calls for medical aid are processed by nationally certified emergency medical dispatchers, who are cross-trained LAFD firefighter-EMTs. Field resources are dispatched in a tiered system through the use of a computer-aided dispatch system. For all calls with potentially life-threatening problems, the dispatch system sends the closest fire-suppression resource (engine or truck), along with the closest paramedic ambulance. For lower-priority calls, paramedic ambulances, EMT ambulances, or fire-suppression resources may be dispatched alone or in varying combinations. Prearrival instructions for the provision of bystander cardiopulmonary resuscitation (CPR) are provided in accordance with those specified by the National Academy of Emergency Dispatch.¹² LAFD responded to 261,619 EMS incidents in 2000.

Data Collection and Processing

Before collection of data, study variables were defined and a standard data collection form was developed for use with each cardiac arrest case. Data collected included inclusion and exclusion criteria at time of arrest, witnessed arrest, bystander CPR, initial cardiac rhythm, return of spontaneous circulation, survival to hospital admission, survival to hospital discharge, and neurologic status for patients with hospital discharge. The data collection period began on July 1, 2000, and ended on June 30, 2001.

A registered nurse was employed full time by the CARE-LA project to serve as study coordinator. Paramedics forwarded to the study coordinator their completed patient care reports for every adult, nontraumatic cardiac arrest patient on whom they attempted resuscitation. Local EMS system protocols require that paramedics establish base hospital contact for medical-arrest victims after performing standard advanced life-support resuscitation actions. To minimize the chances of patients being lost to follow-up, weekly queries were made to every local EMS-affiliated base station. Each base station has an out-of-hospital care coordinator, who is a registered nurse with additional training in EMS. The out-of-hospital care coordinator typically reviews all paramedic runs, especially all cardiac arrests. The CARE-LA study coordinator made contact with each base station's out-of-hospital care coordinator to ensure that each eligible patient was entered into the study database and that outcome data were obtained at each patient's receiving hospital.

All relevant times for each case were obtained from the electronic times captured by the LAFD Fire Information Reporting System. This system electronically captures the time of alarm, and responding personnel strike a computer key on their apparatus when they are en route, on scene, beginning transport to a hospital, and have arrived at the hospital. Each of these times is captured on an incident summary log, which is an electronic file for each incident. Descriptive reports of the interval data from the Fire Information Reporting system are reported only in mean and not median measurements.

Selection of Participants

All confirmed cases of out-of-hospital cardiac arrest were eligible for inclusion. Exclusion criteria were age younger than 18 years and cardiac arrest caused by trauma, drug overdose, drowning, or burns and incineration. Arrests were determined to be due to overdose and therefore excluded by the study authors (ME, SJS) if the paramedics specifically reported “overdose” on their EMS report or there was documented presence of illicit drugs or drug paraphernalia at the scene. Local EMS protocols allow for EMS personnel to withhold resuscitation in the field for persons who are obviously dead, as manifested by lividity, rigor mortis, and decomposition. Only nontrauma cases for which resuscitation was attempted were included in the study database.

Outcome Measures

The primary endpoint of the study was neurologically intact survival at hospital discharge. Secondary endpoints were death or nonneurologically intact survival. Each patient who survived to hospital discharge was assigned a cerebral performance category score using the method described by the Brain Resuscitation Clinical Trial II Study Group by the CARE-LA study coordinator to gauge the patient’s neurologic status.¹⁴ This cerebral performance category assignment was based on physicians’ descriptions of the patients’ neurologic status in the patients’ medical records. All patients were followed up until death in hospital, discharge home, or transfer to a chronic-care facility. Because patients transferred to extended-care facilities all had moderate to severe neurologic deficits (cerebral performance categories 2 to 4), only patients discharged to home or short-term rehabilitation facility (ie, those with a cerebral performance category of 1: no deficits or mild neurologic deficits) were considered to be “neurologically intact survivors.”

The study was approved by the institutional review board of the University of Southern California, which served as the host institution. To obtain patient outcome information, institutional review board approval was also obtained for all 55 hospitals in the greater Los Angeles area to which LAFD transports patients. We also report EMS response-time intervals, which were provided by the LAFD and are publicly available data.

Primary Data Analysis

All data were entered into an Access database (Office 97; Microsoft Corporation, Redmond, WA) and exported into SAS (release 8.2; SAS Institute, Inc., Cary, NC). The incidence of cardiac arrest was calculated by dividing the number of cardiac arrest patients included in the study by the reported total population.¹⁴ We report the neurologically intact survival rate and its 99% confidence interval (CI) based on the binomial distribution. In the Discussion section, we also compare the Los Angeles survival rate with the rates from other cities that have similar EMS system configurations. Furthermore, we discuss the derived relative survival with Los Angeles and its 99% CI for each of these other cities. In discussing and reporting results, we

assumed that a 3% to 5% better survival rate would indicate a clinically significant difference.

RESULTS

Of the 2,021 consecutive cardiac arrest patients on whom resuscitation was attempted, 1,700 (84%) had arrests of presumed cardiac etiology. The median age of those with presumed cardiac arrest was 70 years (interquartile range 55 to 80 years); 1,062 (62%) were men. The incidence of cardiac arrest in Los Angeles was 45 per 100,000 persons.

Figure 1 displays the results using the recommended Utstein template.³ Of the 1,700 patients who met the inclusion criteria, 1,583 had cardiac arrests before EMS arrival. Of these 1,583 patients, there were 18 neurologically intact survivors from bystander-witnessed cardiac arrest and 4 neurologically intact survivors of unwitnessed cardiac arrest, for an overall neurologically intact survival rate of 1.4% (99% CI 0.7% to 2.3%).

Twenty-eight percent (432/1,532) of all patients received bystander CPR. Of the 658 patients who had a witnessed arrest, 250 (38%) received bystander CPR, of whom 8 (3.2%) survived neurologically intact. Among those with witnessed arrests and no bystander CPR, 10 (2.5%) survived neurologically intact (99% CI 0.8% to 4.9%).

There were 250 patients with bystander-witnessed arrest whose initial rhythm was ventricular fibrillation or ventricular tachycardia, of whom 15 were discharged neurologically intact, for a survival rate of 6.0% (99% CI 3.6% to 11.8%).

Of the 117 patients who experienced cardiac arrest in the presence of EMS, 32 (25%) were initially in ventricular fibrillation or ventricular tachycardia, of whom 4 (12.5%) survived neurologically intact. One additional patient who experienced cardiac arrest after EMS arrival had a rhythm of pulseless electrical activity and ultimately survived neurologically intact, for an overall neurologically intact survival rate among arrests occurring after EMS arrival of 4.3% (99% CI 0.9% to 11.7%).

The mean response time (from time of dispatch until arrival of the first unit on scene) was 5.8 minutes. The mean elapsed interval from arrival of firefighter EMT-automated defibrillator-equipped first responders until arrival of paramedics was 3.2 minutes. Figure 2 shows the elapsed core intervals.

There were 25 neurologically intact survivors from the entire study group. They had a mean age of 62 years (± 14.6). Twenty-two (88%) of their cardiac arrests were witnessed, and 14 (56%) patients received bystander CPR. Twenty-one (84%) of these patients were found in ventricular fibrillation on EMS arrival; 2 patients were found in asystole, and 2 patients were in pulseless electrical activity. All neurologically intact survivors had return of spontaneous circulation achieved in the field. Three patients admitted to the hospital were lost to follow-up.

Our findings are compared with those for other cities in North America. The Table shows these published survival rates from witnessed ventricular fibrillation in comparison with that found in Los Angeles. Relative and absolute differences in survival are shown.

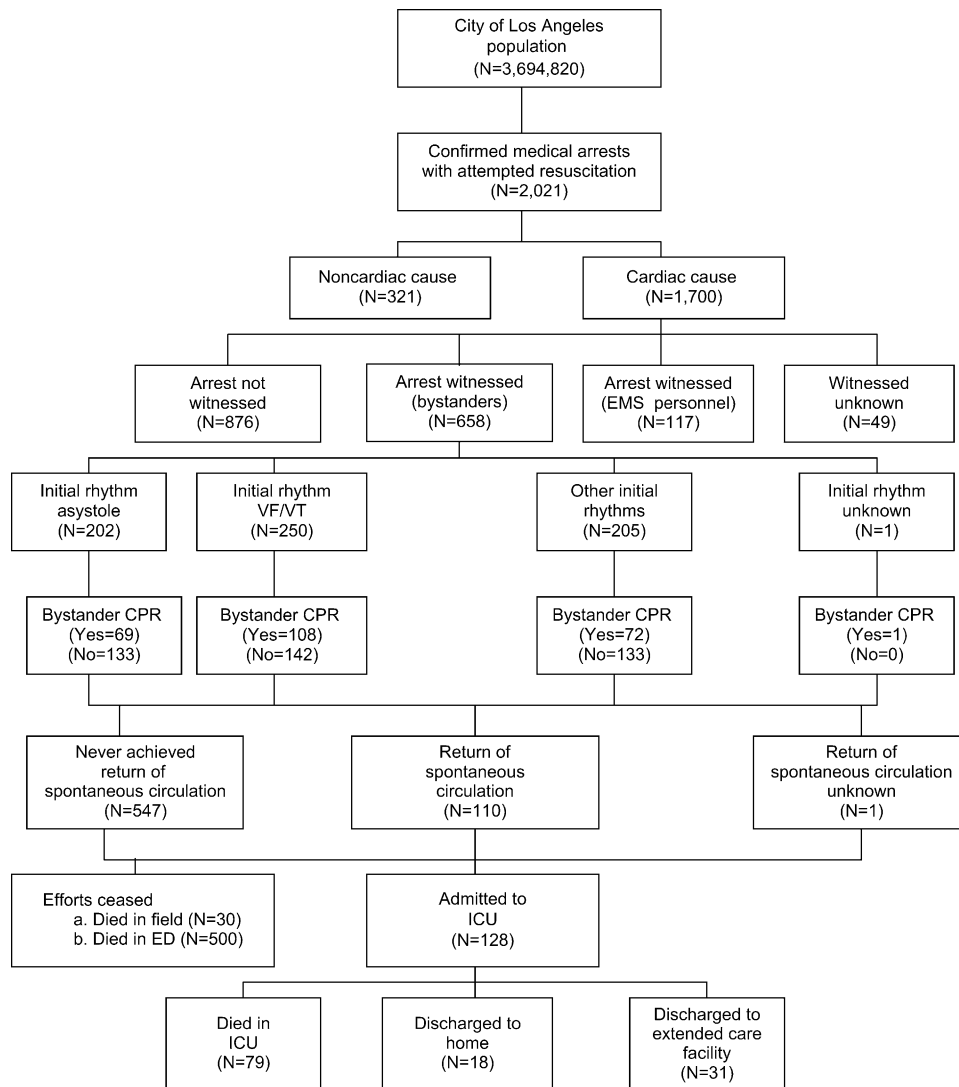


Figure 1. Utstein template for reporting out-of-hospital cardiac arrest (July 1, 2000, to July 1, 2001). VF/VT, Ventricular fibrillation/ventricular tachycardia.

LIMITATIONS

The lack of uniformity with regard to defining survival from cardiac arrest makes comparison of results reported in the literature difficult. In this study, we included only patients who were discharged to home or to an acute rehabilitation facility with good neurologic function as survivors. Other cardiac arrest studies have defined survivors as all patients who were discharged alive from the hospital.^{4,6,10} If we included all patients discharged alive from the hospital (ie, including patients whose cerebral performance category scores were 2, 3, or 4), our survival rate from witnessed ventricular fibrillation would be more than 14% (more than twice the percentage that we do report). Our definition of a neurologically intact survivor was the same as that used in the New York study,⁵ which provides for a more accurate comparison of the results of that study with our data. Furthermore, we excluded patients whose cardiac arrests were witnessed by EMS personnel in the

0	0.7	0.7	5.8	2.0	1.4
Collapse-recognition	Call processing	Dispatch	Response interval	First shock	ALS intervention
		1.4	7.2	9.2	10.4

Figure 2. Timeline (in minutes) for Utstein core events after out-of-hospital cardiac arrests. The top line indicates elapsed mean intervals until the start of each intervention; the bottom line indicates cumulative elapsed time. ALS, Advanced life support.

bystander-witnessed category. This subset of patients tends to have a higher survival rate than non-EMS-witnessed arrests, so including these patients would have skewed our data.

Another limitation is that our method of data collection may not have resulted in capture of all of the cardiac arrests that occurred during the study. Particularly important would be failure to capture a case with neurologically intact survival. However, we believe that using field data and paramedic base hospital data to compare for missing cases allowed for few cases

Table. Comparison of survival from witnessed ventricular fibrillation in Los Angeles with other urban, suburban, and rural EMS systems.*

Location (Year)	Population (Millions)/ Population per Square Mile	No. of Witnessed VF Arrests	No. Survived (%)	Relative Survival (99% CI) [†]	Absolute Difference of Survival, % (99% CI) [†]
Los Angeles (2000)	3.7/7,900	275	19 (6.9)	1.00	
New York City (1990)	7.3/22,000	415	22 (5.3)	0.77 (0.35–1.68)	–2 (–6 to 3)
Chicago (1987)	2.7/11,800	371	15 (4.0)	0.59 (0.25–1.39)	–3 (–8 to 2)
Seattle (1999-2000)	0.56/6,400	303	97 (32.0)	4.63 (2.52–8.52)	25 (17–33)
Miami (1999)	1.2/660	96	23 (24.0)	3.47 (1.66–7.25)	17 (5–29)
Ontario, Canada (1997)	2.7/NA	424	61 (14.4)	2.08 (1.09–3.98)	7 (2–13)

VF, Ventricular fibrillation; NA, not available.
 *Other cities are listed in descending order by population density.
 †Using Los Angeles survival as the reference.

to be potentially lost to the study and that all patients who survived to hospital discharge were captured.

Because the assignment of cerebral performance category scores by the study coordinator was based on descriptions of patients' neurologic status in their medical records, there may have been some inaccuracies. However, all patients discharged home were assigned a cerebral performance category score of 1, which allowed for some uniformity of our definition of a "neurologically intact" survivor, which was the focus of the study.

Finally, our intervals are shown in mean times rather than medians, which might make comparisons of system efficiency between our system and others more difficult.

DISCUSSION

Although variables from published reports of cardiac arrest survival rates from other cities may vary, our findings are similar to those reported for other densely populated cities in North America. Our results closely mirror those reported by Lombardi et al⁵ from New York 10 years ago. The reported overall survival rate from New York City of 1.4%, and 5.3% from witnessed ventricular fibrillation, was not clinically significant (based on 99% CIs) from those reported in our series from Los Angeles (Table). As the first and second most populous cities in the United States, New York and Los Angeles face similar challenges in trying to improve cardiac arrest survival rates. Both cities have heavy traffic congestion, which results in an average of almost 6 minutes of EMS driving time to the incident. Both cities have low rates of bystander CPR (32% in New York and 28% in Los Angeles). This weakness in a critical step in the chain of survival is likely a factor in the poor survival rates in both systems.¹¹ Previous work has shown that resuscitative efforts initiated 5 minutes after collapse result in dramatically lower survival rates.¹⁵

One of the key recommendations made by Lombardi et al⁵ in the New York study was to train and equip first-responder firefighters with automated external defibrillators. Firefighters equipped with automated external defibrillators have served as first responders to reported cardiac arrests in Los Angeles since 1988. Although citywide cardiac arrest survival data were not reported in Los Angeles before the addition of automated external defibrillators, the presence of this presumed critical

component in the chain of survival did not produce survival rates in our study that were clinically different from those found in New York before first-responder automated external defibrillators were implemented.

These findings provide further support for the 3-phase model of cardiac arrest, proposed by Weisfeldt and Becker,¹⁶ which purports that the electrical phase (that most amenable to defibrillation) ends by 4 minutes postarrest. After this interval has elapsed, the patients are already beyond the electrical phase of their arrest and in the circulatory phase, therefore probably benefiting from CPR before defibrillation. Because our first responders typically reached the patient after 5 minutes from the time of collapse, immediate use of an automated external defibrillator before the provision of CPR did not seem to improve survival rates.

Since completion of this study, a number of steps have been taken to improve survival rates from cardiac arrest in Los Angeles. The city has implemented a large public access defibrillation program, which has deployed 580 automated external defibrillators in city-owned buildings, golf courses, libraries, schools, and airports. This public access defibrillation program has included CPR and automated external defibrillator training for thousands of laypersons (city employees). CPR training has also been instituted throughout public high schools. To date, more than 50,000 high school students have completed CPR training. The impact of these measures remains unmeasured, but recently reported results from the national public access defibrillation program suggest that these steps may result in improved survival rates.¹⁷

In light of recent research, cardiac arrest protocols for first responders have changed to emphasize the importance of providing CPR for 1 to 3 minutes before first shock with the automated external defibrillator.^{18,19} The impact of "priming the pump" may result in better neurologically intact survival from cardiac arrest and deserves further investigation.²⁰

Another approach to improve the low rate of bystander CPR in Los Angeles has recently included simplifying the prearrival instructions provided by 911 dispatchers. Rather than trying to instruct the caller (the untrained would-be rescuer) in providing mouth-to-mouth ventilations followed by chest compressions, our emergency medical dispatchers have begun

providing instructions for compression-only CPR. Preliminary data suggest that this method will not only improve the rate of bystander CPR by providing simpler instructions but also improve resuscitation rates by focusing on early circulation.²¹

Finally, our results, like those reported from New York and Chicago, demonstrate the need for large, multicenter trials on cardiac arrest to evaluate which interventions result in improved survival. We hope programs such as the National Institutes of Health initiative establishing a multicenter resuscitation research consortium to conduct research in cardiac arrest will provide these answers during the next several years.²²

We conclude that in Los Angeles, slightly more than 1 of 100 out-of-hospital cardiac arrest patients survive neurologically intact to be discharged home. As with other large EMS systems, our data suggest that there are characteristics, both socioeconomic and geographic, that may be present in the nation's largest cities that account for these low survival rates. Because a large percentage of the US population resides in densely populated urban areas, this problem comprises a major public health issue. Further research is needed to evaluate the specific factors that lead to low neurologically intact survival from cardiac arrest and the impact of ongoing local changes in improving survival from out-of-hospital cardiac arrest.

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Address for correspondence: Marc Eckstein, MD, Department of Emergency Medicine, Los Angeles County–University of Southern California Medical Center, 1200 N. State Street, Room 1011, Los Angeles, CA 90033; 213-978-3741, fax 213-978-3818; E-mail eckstein@usc.edu.

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