

# CARDIAC ARREST SURVIVAL IS RARE WITHOUT PREHOSPITAL RETURN OF SPONTANEOUS CIRCULATION

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## ABSTRACT

**Background.** Emergency medical services (EMS) are crucial in the management of out-of-hospital cardiac arrest (OHCA). Despite accepted termination-of-resuscitation criteria, many patients are transported to the hospital without achieving field return of spontaneous circulation (ROSC). **Objective.** We examine field ROSC influence on OHCA survival to hospital discharge in two large urban EMS systems. **Methods.** A retrospective analysis of prospectively collected data was conducted. Data collection is a component of San Antonio Fire Department's comprehensive quality assurance/quality improvement program and Cincinnati Fire Department's participation in the Cardiac Arrest Registry to Enhance Survival (CARES) project. Attempted resuscitations of medical OHCA and cardiac OHCA for San Antonio and Cincinnati, respectively, from 2008 to 2010 were analyzed by city and in aggregate. **Results.** A total of 2,483 resuscitation attempts were evaluated. Age and gender distributions were similar between cities, but ethnic profiles differed. Cincinnati had 17% ( $p = 0.002$ ) more patients with an initial shockable rhythm and was more likely to initiate transport before field ROSC. Overall survival to hospital discharge was 165 of 2,483 (6.6%). More than one-third (894 of 2,483, 36%) achieved field ROSC. Survival with field ROSC was 17.2%

(154 of 894) and without field ROSC was 0.69% (11 of 1,589). Of the 11 survivors transported prior to field ROSC, nine received defibrillation by EMS. No asystolic patient survived to hospital discharge without field ROSC. **Conclusion.** Survival to hospital discharge after OHCA is rare without field ROSC. Resuscitation efforts should focus on achieving field ROSC. Transport should be reserved for patients with field ROSC or a shockable rhythm. **Key words:** cardiac arrest; survival; prehospital; emergency medical services

PREHOSPITAL EMERGENCY CARE 2012;16:451-455

## INTRODUCTION

The European Resuscitation Council and the American Heart Association have invested tremendous study and resources in an effort to improve the poor survivability of out-of-hospital cardiac arrest (OHCA). The rapid return of spontaneous circulation (ROSC) is paramount, and must be followed by intervention to reverse the cause of the arrest. Survival from OHCA is highly time-sensitive and requires aggressive intervention by both the lay public and health care professionals.<sup>1,2</sup>

Emergency medical services (EMS) are typically the initial medical professionals to intervene and are tasked with the primary goals of establishing ROSC, providing the appropriate postresuscitative care, and transporting the patient to an appropriate postresuscitation care facility.<sup>3</sup> Despite the existence of prehospital termination-of-resuscitation (TOR) protocols,<sup>4</sup> EMS systems have variable practices in the disposition of OHCA patients who fail to achieve ROSC.<sup>5,6</sup> In October 2011, the National Association of EMS Physicians released a position statement indicating that EMS systems should consider TOR of any patient suffering OHCA if the patient exhibits unwitnessed arrest, no shockable rhythm, and no field ROSC.<sup>7</sup>

This study aimed to determine rates of survival to hospital discharge in patients transported to the hospital without achieving ROSC in the field in two distinctly different large urban EMS systems.

## METHODS

This was a retrospective analysis of prospectively collected data of OHCA patients in two large ethnically diverse cities in the United States over three years (2008-2010). Prehospital care was dictated by local

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Received January 27, 2012, from the Department of Emergency Health Sciences, University of Texas Health Science Center at San Antonio (DAW, CAM, CV), San Antonio, Texas; the San Antonio Fire Department (DAW, CAM, CV), San Antonio, Texas; the Department of Emergency Medicine, University of Cincinnati (LC, JTM), Cincinnati, Ohio; and the Cincinnati Fire Department (LC, JTM), Cincinnati, Ohio. Revision received April 16, 2012; accepted for publication April 22, 2012.

Presented in part as an abstract at the American College of Emergency Physicians Research Forum, San Francisco, California, October 2011.

The authors wish to acknowledge the daily lifesaving efforts of the firefighters, EMTs, and paramedics of the San Antonio and Cincinnati Fire Departments. Funding was provided, in part, by the San Antonio Office of the Medical Director. The CARES data registry is a collaborative effort with the Centers for Disease Control and Prevention, the American Heart Association, and emergency medical services and hospitals across the United States.

All authors report no conflict of interest.

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doi: 10.3109/10903127.2012.695435

protocol and/or in accordance with accepted basic and advanced life support guidelines.<sup>8,9</sup> Both entities received approval from their respective institutional review boards.

## Setting

San Antonio Fire Department utilizes a dual response to OHCA, including a four-person fire company and two dual-paramedic-staffed mobile intensive care ambulances. The fire department is the sole 9-1-1 provider for the seventh largest city in the United States and services approximately 1.4 million residents within a 460-square-mile area with approximately 130,000 medical responses per year. Approximately half of the fire companies are staffed with at least one paramedic with advanced capabilities.

The Cincinnati Fire Department provides a similar response to cardiac arrest. During the study period, this response included the closest four-person fire company and a single dual-paramedic-staffed ambulance; a paramedic supervisor frequently responded as well. Approximately half of the fire companies were staffed with at least one paramedic; no-paramedic fire companies were equipped with an automated external defibrillator. The fire department is the sole 9-1-1 provider for the city, with a nighttime population of approximately 300,000 over 78 square miles with approximately 53,000 annual medical responses.

## Data Collection and Processing

The San Antonio Fire Department Office of the Medical Director (OMD) utilizes an in-house cardiac arrest database that is populated from post-cardiac arrest debriefings; database elements are largely based on Utstein criteria.<sup>10</sup> Debriefings are conducted by a member of the OMD and occur at the conclusion of any case where paramedics initiate resuscitative efforts in the prehospital setting. Hospital survival is determined through hospital records, review of obituaries, and the Social Security Death Index. All OHCA of presumed medical etiology are included in the database. Specific to this project, the database includes patient demographic information, resuscitative efforts utilized, incidence of any ROSC and sustained ROSC (defined as at least 60 beats/min for a minimum of 5 minutes), decision to transport and receiving facility if transported, and survival to hospital discharge.

The Cincinnati Fire Department participates in the Cardiac Arrest Registry to Enhance Survival (CARES) data registry<sup>9,10</sup> and the same data were abstracted from this source. Out-of-hospital cardiac arrests of presumed cardiac etiology are included in CARES.

## Data Analysis

Cincinnati participates in CARES, which has stringent oversight to ensure completeness of the data entered. San Antonio utilizes a rigorous postevent debriefing to ensure a complete dataset. We had no missing data elements for the included variables. Data were analyzed per agency and in aggregate. Percentage or mean  $\pm$  standard deviation was determined for all variables. The statistical significance for continuous variables (defined as  $p < 0.05$ ) was determined using Student's *t*-test. Differences between groups were compared using chi-square. Data were managed with Microsoft Excel (Microsoft Corp., Redmond, WA) and analyzed with SPSS version 20 (IBM, Armonk, NY).

## RESULTS

During the three-year study period, 2,483 resuscitation attempts were included, 1,933 from San Antonio and 550 from Cincinnati (Fig. 1). The population demographics were similar, with the exception of ethnicity (Table 1). However, the rates of bystander cardiopulmonary resuscitation (CPR), initial shockable rhythm, field ROSC, and survival to discharge were significantly different (Table 1).

Overall survival to hospital discharge during the study period was 6.6% (165/2,483), with 25% (41/165) of survivors presenting in asystolic arrest. Field ROSC

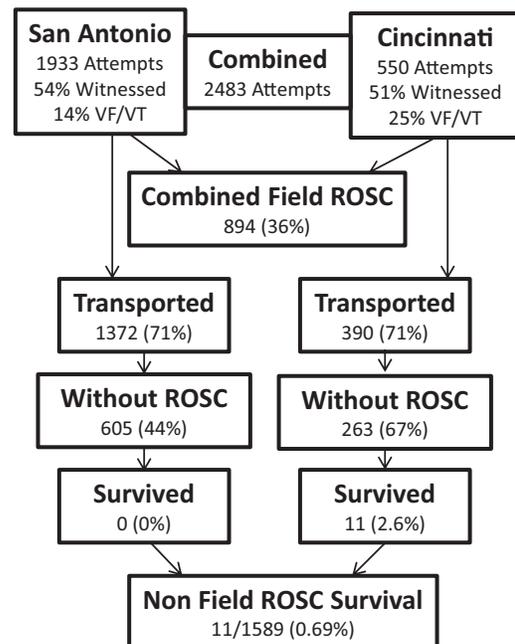


FIGURE 1. Schematic demonstrating the flow of patients with out-of-hospital cardiac arrest during the study period. ROSC = return of spontaneous circulation; VF/VT = ventricular fibrillation/ventricular tachycardia.

TABLE 1. Characteristics of Patients at the Study Sites and Selected Features of the Cardiac Arrests Included in the Study

	San Antonio	Cincinnati	p-Value*
Age—mean ( $\pm$ SD), years	64 ( $\pm$ 17)	64 ( $\pm$ 15)	
Age of survivors—mean ( $\pm$ SD), years	59 ( $\pm$ 16)	60 ( $\pm$ 14)	
Age of nonsurvivors—mean ( $\pm$ SD), years	65 ( $\pm$ 16)	64 ( $\pm$ 16)	
Gender—male	1,179 (61%)	324 (59%)	
Race/ethnicity			
Hispanic	1,005 (52%)	5 (1%)	0.001
White	677 (35%)	237 (43%)	
African American	213 (11%)	253 (46%)	0.003
Witnessed arrest	1,024 (53%)	281 (51%)	
Bystander CPR	889 (46%)	193 (35%)	0.01
VF/VT initial rhythm	276 (14%)	139 (25%)	0.02
Field ROSC	767 (40%)	127 (23%)	0.001
Transported to ED	1,372 (71%)	390 (71%)	
Survival to hospital discharge	108 (5.6%)	57 (10%)	<0.001
Survival to hospital discharge without field ROSC	0 (0%)	11 (2%)	0.01

Data are expressed as number (percentage) unless otherwise specified.

Population and area statistics per 2010 census data.

\*p-Values are listed only for those characteristics with statistically significant difference between the two sites.

CPR = cardiopulmonary resuscitation; ED = emergency department; ROSC = return of spontaneous circulation; SD = standard deviation; VF/VT = ventricular fibrillation/ventricular tachycardia.

was achieved in 36% (894/2,483) and survival with field ROSC was 17.2% (154/894). Survival to hospital discharge without field ROSC was 0.69% (11/1,589). The non-field ROSC survivors represented a very small portion of the overall survivors, 6.7% (11/165) (Fig. 2).

All survivors without field ROSC were in the Cincinnati cohort; eight of 11 (72%) had witnessed arrests and two of 11 (18%) experienced cardiac arrest in the presence of EMS personnel. Additionally, eight of 11 (72%) had an initial shockable rhythm, with nine of the 11 (82%) having received at least one defibrillation during the course of resuscitation. None of the non-field ROSC survivors were found in asystole. Of the 11 survivors without field ROSC, six had good neurologic

function (i.e., cerebral performance category [CPC] 1) at the time of hospital discharge, despite only one's having received bystander CPR prior to the arrival of the first responder. Two patients had moderate cerebral disability (CPC 2) and three patients were in comas (CPC 4). It is noteworthy that an additional 23 patients without field ROSC from the Cincinnati cohort survived to hospital admission but died prior to discharge (CPC 5).

While there were no differences in the mean age with the intercity analysis, there was a difference in the mean age of the survivors vs. the nonsurvivors: 59 ( $\pm$ 16) vs. 65 ( $\pm$ 16) years ( $p = 0.002$ ), with both cities in aggregate (Table 1). The average age for the non-field ROSC survivors was 58 ( $\pm$ 10) years.

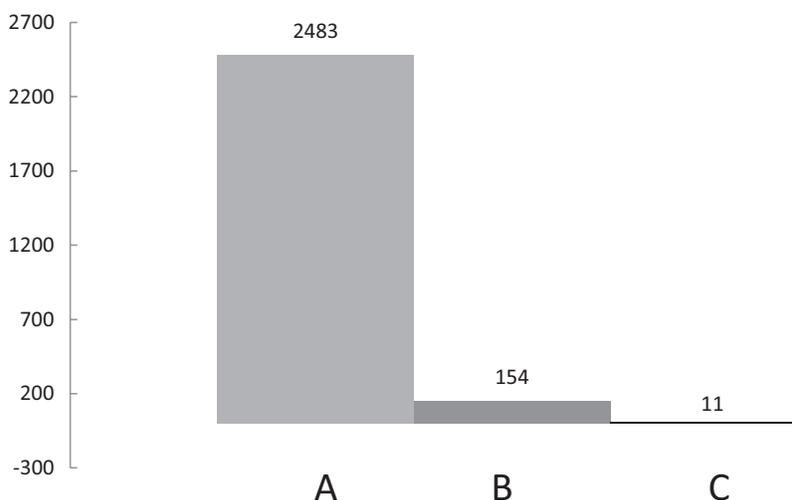


FIGURE 2. Dual-site aggregate data. **A**) Individual resuscitation attempts; **B**) individual survival to hospital discharge with field return of spontaneous circulation (ROSC); and **C**) individual survival to hospital discharge without field ROSC.

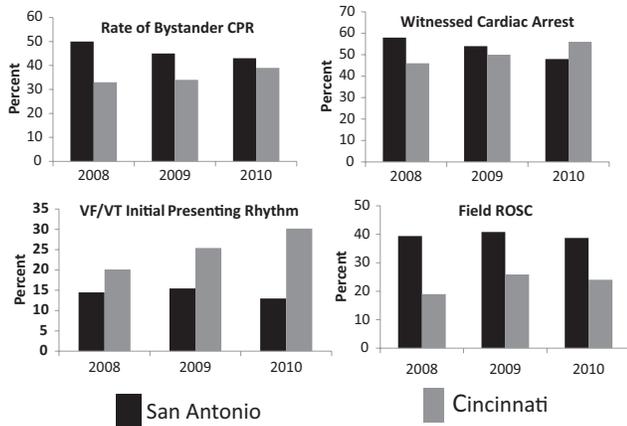


FIGURE 3. Site comparison of selected characteristics of out-of-hospital cardiac arrest with potential to impact survival. CPR = cardiopulmonary resuscitation; ROSC = return of spontaneous circulation; VF/VT = ventricular fibrillation/ventricular tachycardia.

Both cities transported approximately 70% of OHCA patients, but Cincinnati was much more likely to transport patients prior to obtaining ROSC. Cincinnati also had a 17% higher rate of all OHCA with a shockable initial presenting rhythm (14.3% vs. 25.3% [ $p = 0.002$ ]) (Fig. 3). The overall field TOR rate was 30%.

## DISCUSSION

Survival to hospital discharge in patients transported to the hospital without achieving ROSC in the field in two distinctly different large urban EMS systems is very low (11/1,589, 0.69%). These results generally support the concept of prehospital TOR policies,<sup>4</sup> but TOR should not be obligatory. Transport decisions should be based on the whole clinical picture.

Transportation of OHCA victims is not a benign process. Aggressive treatment of the OHCA victim in the field before transport, compared with rapid transportation, is associated with improved outcomes.<sup>1,3,4,6,11–13</sup> Other considerations include the safety of the public and the EMS crew, the difficulty of performing adequate chest compressions and ventilation while in a moving ambulance, the decreased availability of emergency department beds, and the fiduciary considerations of continuing to consume resources in a futile situation.

During this study period, 1762 cardiac arrest patients were taken to the hospital even though only 894 patients achieved ROSC prior to transport. Both cities have TOR criteria in which achievement of sustained ROSC (at least 60 beats/min for 5 minutes) is a crucial part. The available data do not allow recreation of the medical decision making of the treating EMS providers as to why TOR did not occur (e.g., arrest in a public place, order of online medical control). However, if ROSC had been the sole threshold to TOR, the transport rate would have been halved.

A problematic OHCA scenario is refractory ventricular fibrillation/ventricular tachycardia (VF/VT). San Antonio allows aggressive treatment, including dual-sequential defibrillation, which may result in conversion of this rhythm into either a perfusing or nonshockable rhythm. Cincinnati's protocols, on the other hand, encourage rapid transportation to the hospital; refractory VF/VT is a contraindication to TOR. This practice may explain the higher non-ROSC hospital transport rate for Cincinnati.

Work by Morisson et al. has shown that in the absence of field ROSC, an initial shockable rhythm, or EMS-witnessed arrest, OHCA patients had only a 0.5% survival.<sup>14</sup> This tool, known as the basic life support (BLS) TOR criteria, consists of information available to EMS providers of all levels. However, its use is not restricted to non-advanced life support (ALS) providers. Our data closely agree with those of Morrison and colleagues in survival percentages and in survivor profile. Additionally, none of the 11 non-field ROSC patients in our cohort would have been a candidate under the TOR clinical rules in that all patients had a witnessed arrest and/or had VF/VT as the presenting rhythm. Importantly, evaluation of the BLS TOR criteria was not the purpose of this study; our objective was to determine the eventual outcomes of patients transported to the hospital without first achieving prehospital ROSC.

Implementation of any TOR protocols requires consideration of many issues to gain acceptance by providers and the community. Adding additional medications, emphasizing procedures to optimize treatment of the easily correctable conditions, and providing education for managing the scene after TOR are all easy strategies to reduce futile transports.<sup>15</sup> Coordination with local law enforcement agencies can be beneficial for supervision of the deceased before the coroner makes a determination of the ultimate disposition of the deceased and/or the need for forensic autopsy. Additionally, the San Antonio Fire Department is developing a policy that recommends transport without lights and sirens with the normal flow of traffic for any non-field ROSC patients taken to the hospital.

## LIMITATIONS

This study is limited by the retrospective nature of the analyses. However, all data were collected prospectively using established practices, which should blunt this limitation. The large cohort, coupled with consistent data definitions of the common data elements, allowed pooled analysis.

Another limitation to this study is that both of the datasets fail to include some or part of important time intervals, including response time, time spent on scene, and time from dispatch to hospital arrival. Response times may be a reason for the differing rates

of VF/VT rhythms; however, unmeasured variables such as ethnic and socioeconomic differences cannot be excluded.

## CONCLUSION

Survival to hospital discharge after OHCA is exceedingly rare without achieving ROSC prior to hospital arrival. Resuscitation efforts should focus on achieving field ROSC. Transport should be reserved for patients with field ROSC and/or a shockable rhythm, as there appears to be no benefit to transporting patients who are asystolic on presentation.

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