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Selected Topics: Prehospital Care

MANDATED 30-MINUTE SCENE TIME INTERVAL CORRELATES WITH IMPROVED RETURN OF SPONTANEOUS CIRCULATION AT EMERGENCY DEPARTMENT ARRIVAL: A BEFORE AND AFTER STUDY

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☐ Abstract—Background: Conflicting ideas exist about whether or not Emergency Medical Service (EMS) personnel should treat a cardiac arrest on scene or transport immediately. Objective: Our aim was to examine patient outcomes before and after an urban EMS system implemented a protocol change mandating a 30-min scene time interval (STI) for out-of-hospital cardiac arrest (OHCA). Methods: This was a retrospective, single-center, observational study of OHCA patients before and after an EMS protocol change mandating resuscitation on scene. Data were retrieved from an EMS cardiac arrest database for all adults with non-traumatic OHCA between January 2015 and August 2016. Descriptive statistics were used to summarize the study population, and a regression model was used to determine the associations of the protocol with the return of spontaneous circulation (ROSC). Results: A total of 633 patients were included in the study population, which was primarily male (61.3%) with a mean age of 65 years. After the 30-min STI was implemented, ROSC from OHCA increased to 40.1% of cases compared to 27.3% before the protocol change (*p* = 0.001; 95% confidence interval [CI] 0.053–0.203). The STI increased from 19 min 23 s to 29 min 40 s in the pre and post periods, respectively (*p* < 0.001). Regression indicated that the protocol change was independently associated with an improved chance of ROSC (OR 1.81; 95% CI 1.23–2.64). Conclusions: A protocol change mandating a 30-min STI in OHCA correlated with increased STI and increased ROSC. While increased ROSC may not always equate with positive neurologic outcome, logistic regression indicated that the protocol change was independently associated with improved ROSC at emergency department arrival.

☐ Keywords—out-of-hospital cardiac arrest; scene time interval; return of spontaneous circulation

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INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) is the most common form of cardiac arrest, with more than 325,000 cases treated by emergency medical services (EMS) in the United States annually. Despite a steady increase in

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survival over the last 10 years, the chance of survival to hospital discharge after OHCA is still low, at approximately 10% (1,2). Recent efforts have focused on strategies to improve not only overall survival but also good neurologic function. Several factors that influence outcomes in OHCA and consistently show improved return of spontaneous circulation (ROSC) and good neurologic outcome include non-traumatic etiology, witnessed arrest, delivery of high-quality cardiopulmonary resuscitation (CPR), short time to bystander or EMS response, or presence of a shockable rhythm (1–7). It is not clear, however, to what extent the time on scene with EMS can affect survival.

Conflicting ideas and data exist on the "scoop and go" vs. "stay and play" methods. Advocates for longer scene time interval (STI) state that crews should stay on scene to provide high-quality CPR until either ROSC occurs or they terminate the resuscitation. Simulated models have shown that the quality of CPR decreases during transport compared to on scene, which could potentially negatively affect ROSC (8–11). In analyses of real resuscitations, only small variability or no difference was found in CPR quality based on location, however, these studies included continuous CPR feedback, which is not available in many EMS systems (12–14). Additionally, while it consistently shows a decrease in transport times, emergent transport (i.e., lights and sirens) has been regarded as dangerous and can increase the risk of ambulance crashes (15).

On the other hand, advocates for shorter STI state that crews should transport immediately to the emergency department, as data show potential harm for patients who have aggressive advanced prehospital maneuvers, for example, airway placement (16). To date, the best available evidence supports an intermediate STI (8–16 min), however, these data are primarily from areas where advanced life support (ALS) teams may not necessarily be readily or consistently available and overall survival rates are very low (17).

Goals of This Investigation

There is a paucity of evidence suggesting an appropriate STI length in urban environments where EMS can provide advanced care in the field. Therefore, the purpose of this observational study was to examine patient outcomes before and after an urban EMS system implemented a protocol change to increase the STI for OHCA.

MATERIALS AND METHODS

This study was approved by the University of Arkansas for Medical Sciences (UAMS) Institutional Review Board.

This was a pre–post, retrospective, single-service, observational study of cardiac arrest patients. Metropolitan Emergency Medical Services (MEMS) is the only public ambulance service that serves the Little Rock, AR area. For OHCA, an ALS team consisting of at least one paramedic is dispatched to every scene. As part of routine quality improvement (QI), electronic run sheets on all cardiac arrest patients from time of 9-1-1 call to time of arrival at the hospital are reviewed and all variables and run information are abstracted into a database managed by MEMS administrators. This is typically done by the QI officer in the days following the cardiac arrest. A de-identified dataset from this database was provided to the study team for data analysis.

In November 2016, in an attempt to focus more on continuous, quality, uninterrupted CPR, EMS medical direction approved a protocol change mandating a 30-min STI for cardiac arrest patients before initiating transport. Before the protocol change, the STI for OHCA was left to the discretion of the treating ALS team, though they were encouraged to transport immediately. Additionally, there was no option for termination of resuscitation (TOR) before the protocol change. Patients were either declared dead on arrival, or they were resuscitated and transported. All ALS and basic life support (BLS) team members received mandatory training on the protocol change, and there were no other significant changes to other protocols or training that occurred during the study period. The new scene time requirement did not apply to pediatric cardiac arrest, traumatic arrest, if there were scene safety concerns, or if the ALS team felt they could not appropriately carry out ALS procedures due to scene conditions.

The 30-min STI requirement was implemented as follows: an ALS team would be called to an OHCA. Unless the patient met one of the exclusion criteria, the team was obligated to resuscitate the patient on scene until ROSC was achieved or 30 min had elapsed. Immediate transport to an emergency department was indicated whenever ROSC occurred regardless of how much time they had spent on scene. If after the 30-minute STI had passed, the ALS team could consider contacting medical control for TOR if the following conditions were met: the patient had been pulseless and apneic on arrival, had a patent i.v. and airway, had never achieved ROSC or had signs of life, and remained in an agonal or asystolic rhythm. Without these criteria, the patient was required to be transported to an emergency department (ED). This study compares outcomes before and after implementation of the new 30-min STI protocol.

All adults who were aged 18 years or older with non-traumatic OHCA between January 2015 and August 2016 were included. Cases with missing information were excluded from the study sample. Data were retrieved in de-identified form from the cardiac arrest database managed by the EMS QI officer. Study staff did not have access to the individual records.

The main exposure of interest was the implementation of the 30-min STI. The primary outcome was out-of-hospital ROSC. Out-of hospital ROSC was defined as ED arrival with sustained spontaneous circulation, which was identified by database review. The secondary outcome was the change in STI, defined as time of arrival on scene to time leaving the scene. These outcomes were chosen a priori and based on the list of available database variables, which were ultimately based on the variables in the EMS run sheet. Unfortunately patient-centered variables like survival to hospital discharge and neurologic outcome were not variables in the EMS database and therefore could not be in our study outcomes.

We collected information on demographic factors (age and gender), proportion of witnessed cardiac arrests, provision of BLS, time of arrest to CPR, defibrillation prior to EMS, STI (divided into 10-min increments), provision of CPR on scene, initial rhythm on EMS arrival (categorized as shockable or non-shockable), defibrillation by EMS, and delivery of an advanced airway (endotracheal intubation or supraglottic device). Witnessed location was categorized into public and private settings. Public settings included jail, medical facility, nursing home, or public place. Chest compression fraction was not reported, as it is not an option on the ALS team runsheet.

Analysis

Descriptive statistics were used to summarize the study population and are reported as proportion for categorical population and binary data, and as mean and standard deviation for continuous data. Bivariate analysis was used to test for differences between the subgroup means for pre protocol and post protocol. The differences between the group means on each measure were analyzed for direction and statistical significance using *t*-tests for continuous variables and χ^2 tests for categorical variables.

A regression model was used to determine the associations of the protocol with the study outcome. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were calculated using multivariable logistic regression analysis. We adjusted for age, gender, arrest location (public or private), witnessed arrest (witnessed by trained individual, witnessed by untrained individual, witness unknown), provision of BLS, time of arrest (categorized into 0–4 min, 4–8 min, >8 min, and time unknown), defibrillation prior to EMS, the initial cardiac rhythm on EMS arrival (shockable or nonshockable), and advanced airway placement as potential confounders in the model. Correlation analysis was performed to identify potential multicollinearity among the independent variables, which was not detected in this analysis. The model fit was assessed with Hosmer-Lemeshow goodness-of-fit tests. Statistical significance was set at $\alpha = 0.05$ for all analyses. The analysis was conducted using Stata, version 14.0 (StataCorp, College Station, TX, 2011).

RESULTS

Characteristics of Study Subjects

A total of 977 OHCAs were recorded during the study period. Three hundred and forty-four patients were excluded due to age < 18 years, traumatic arrest, or missing data. The remaining sample consisted of 633 patients. Figure 1 presents inclusion and exclusion flow chart for the study population.

Table 1 presents the descriptive statistics for the sample overall and dichotomized by the pre- and post-study period. The study sample consists of 61.3% male and a mean age of 64.6 years (standard deviation 16.2 years). The majority (74.6%) of the OHCAs occurred in private locations, and 62.7% of the arrests were witnessed by an untrained individual. The initial rhythm on EMS arrival was non-shockable for majority of patients (78%).

Main Results

A comparison between the pre- and post-study period (Table 1) indicates significant differences between witnessed arrest, BLS, time to arrest, STI, defibrillation by EMS, and ROSC. Overall ROSC from OHCA increased in the post period (40.1%) compared to the pre period (27.3%) ($p = 0.001$; 95% CI 0.053–0.203). Additionally, the STI increased from 19 min 23 s to 29 min 40s in the pre and post periods, respectively ($p < 0.001$). The

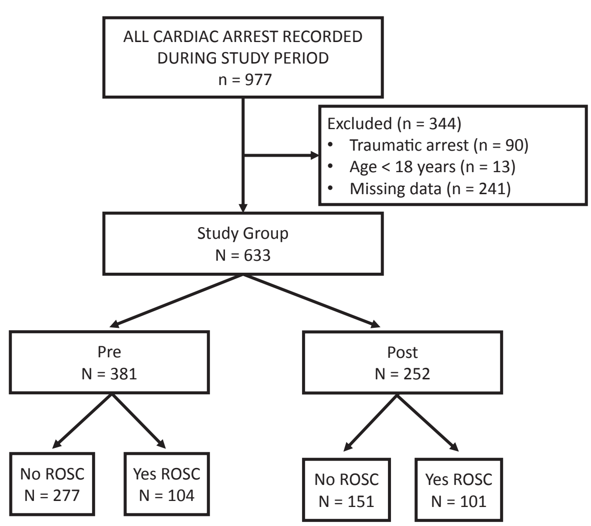

Figure 1. Flowchart of patients included in the study. ROSC, return of spontaneous circulation.

Table 1. Demographic and Out-of-Hospital Data for Patients Experiencing Out-of-Hospital Cardiac Arrest Before and After Protocol Intervention

Characteristics	Overall	Pre Period	Post Period	95% Confidence Interval	*p* Value
Total, n	633	381	252	—	—
Male, n (%)	388 (61.3)	238 (62.5)	150 (59.5)	−0.107 to 0.048	0.457
Age, mean (SD)	64.6 (16.2)	64.1 (16.2)	65.3 (16.1)	−3.001 to 1.521	0.339
Witness location, n (%)					0.696
Public*	161 (25.4)	99 (26.0)	62 (24.6)	—	
Private	472 (74.6)	282 (74.0)	190 (75.4)	−0.075 to 0.063	
Witnessed arrest, n (%)					0.005
Witnessed by trained individual	62 (9.8)	27 (7.1)	35 (13.9)	0.018 to 0.118	
Witness by untrained individual	397 (62.7)	255 (66.9)	142 (56.3)	−0.034 to 0.109	
Witness unknown	174 (27.5)	99 (26.0)	75 (29.8)	−0.183 to −0.028	
BLS, n (%)					0.000
BLS provided	275 (43.4)	142 (37.3)	133 (52.8)	0.077 to 0.234	
Time of arrest to CPR, n (%)					0.001
0–4 min	297 (46.9)	173 (45.4)	124 (49.2)	−0.041 to 0.117	
4–8 min	89 (14.1)	57 (15.0)	32 (12.7)	−0.077 to 0.032	
> 8 min	70 (11.1)	56 (14.7)	14 (5.6)	−0.137 to −0.046	
Time unknown	177 (28.0)	95 (24.9)	82 (32.5)	0.004 to 0.148	
AED defibrillate prior to EMS, n (%)	71 (11.2)	43 (11.3)	28 (11.1)	−0.052 to 0.048	0.946
Initial rhythm on EMS arrival, n (%)					0.150
Shockable	139 (22.0)	91 (23.9)	48 (19.0)	−0.113 to 0.016	
Defibrillated by EMS, n (%)	189 (29.9)	132 (34.6)	57 (22.6)	−0.11 to −0.050	0.001
Advanced airway, n (%)	428 (67.6)	258 (67.7)	170 (67.5)	−0.077 to 0.072	0.946
ROSC, n (%)	205 (32.4)	104 (27.3)	101 (40.1)	0.053 to 0.203	0.001

AED = automated external defibrillator; BLS = Basic Life Support; CPR = cardiopulmonary resuscitation; EMS = Emergency Medical Services; ROSC = return of spontaneous circulation; SD = standard deviation.
* Public refers to jail, medical facility, nursing home, public place.

remaining variables, age, gender, witness location, defibrillation prior to EMS, initial shockable rhythm, and provision of an advanced airway were not significantly different in the pre and post study period.

The results from the multiple logistic regression (OR and 95% CIs) are presented in Table 2 and also using a forest plot (Figure 2). After controlling for patient demographics and clinical characteristics, the results indicate that the implementation of the protocol in the post-study period was independently associated with an increase in ROSC (OR 1.55; 95% CI 1.08–2.24). Arrest witnessed by trained individual (OR 2.87; 95% CI 1.31–6.30) and the provision of BLS (OR 2.07; 95% CI 1.40–3.07) both increased the probability of ROSC for an OHCA.

DISCUSSION

This goal of this study was to determine if there was a benefit to spending more time on scene during OHCA vs. using crew discretion on the decision of when to transport to the ED. We used data from a metropolitan EMS database to investigate and compare ROSC in cardiac arrest patients before and after a protocol change mandating a 30-min STI. Our results demonstrated that not only was there an associated increase in scene time with the protocol change, but there was also an independent positive association with ROSC.

To our knowledge, this is the first study investigating the effect of specifying a long STI in an EMS protocol. Several studies have examined whether or not there is a time after which patients do not really benefit from additional minutes of CPR. A study by Nehme et al. analyzed 1035 patients with OHCA and found that those with more than 32 min of prehospital CPR had a < 1% chance of survival to hospital discharge (18). The study also found that CPR given longer than 32 min increased the likelihood of ROSC, but survival rate was mostly unchanged (18). A similar study by Funada et al. studied 35,709 patients with OHCA. They also found that a prehospital CPR duration of 32 min identified 99% of patients who survived to hospital discharge, but that a CPR duration > 25 min was associated with a < 1% chance of being discharged with a cerebral performance category (CPC) of 1–2 (19). A third study by Goto et al. reviewed 17,238 patents with ROSC after OHCA and found that 99% of the patients with CPC of 1–2 had prehospital CPR duration of ≤ 35 min (20). In all three of these studies, though, prehospital CPR time was defined as time of arrival on scene until ROSC, and it was not specified whether ROSC occurred on scene or during transport. A direct comparison to our results is difficult, but these data potentially support the use of a 30-min resuscitation time limit, after which TOR can be considered.

Shin and colleagues investigated EMS scene times in 3594 patients with OHCA, looking at both ROSC and

Table 2. Determinants of Return of Spontaneous Circulation Using a Multiple Logistic Regression Model

Characteristics	Odds Ratio	*p* Value	95% Confidence Interval
Age	.999	0.876	0.988–1.010
Male	.741	0.109	0.514–1.069
Public location	.905	0.637	0.598–1.369
Arrest witnessed by trained individual*	2.867	0.009	1.306–6.295
Arrest witnessed by untrained individual*	1.571	0.129	0.877–2.816
Basic Life Support provided	2.074	0.000	1.402–3.070
Time of arrest to CPR: 0–4 min†	1.307	0.367	0.731–2.334
Time of arrest to CPR: 4–8 min†	.931	0.836	0.470–1.842
Time of arrest to CPR: > 8 min†	.746	0.432	0.359–1.549
Defibrillation prior to EMS	1.603	0.136	0.863–2.979
Shockable initial rhythm on EMS arrival	1.764	0.073	0.949–3.277
Defibrillated by EMS	.731	0.241	0.433–1.234
Advanced airway	.933	0.723	0.635–1.371
Post-protocol change	1.554	0.019	1.075–2.246

CPR = cardiopulmonary resuscitation; EMS = emergency medical services.
* Referent is arrest witness unknown.
† Referent is time of arrest to CPR: Unknown.

neurologic outcomes (17). They retrospectively studied two EMS systems, one in Japan where they are encouraged to "scoop and run," and one in Korea where they are encouraged to stay on scene for 10 min or three to four cycles of CPR. Their overall findings suggested that an intermediate STI (8–16 min) was more likely to result in good neurologic outcome determined as a CPC score of 1 or 2. Interestingly, they also found that the long STI group (> 16 min) was associated with higher ROSC than the intermediate group, but not necessarily better neurologic outcome. In this long scene time group, the mean STI was 20 min (17). Another study with slightly different findings has been published from Korea, showing that in 41,054 cases of OHCA, an STI of 4–8 min led to the highest rate of CPC 1–2 at discharge, and that, in general, increased STI led to poorer outcomes (21). These two studies differ from ours, however, in that endotracheal intubation and Advanced Cardiac Life Support medications are not administered as consistently as in our urban EMS systems. In addition, both studies had

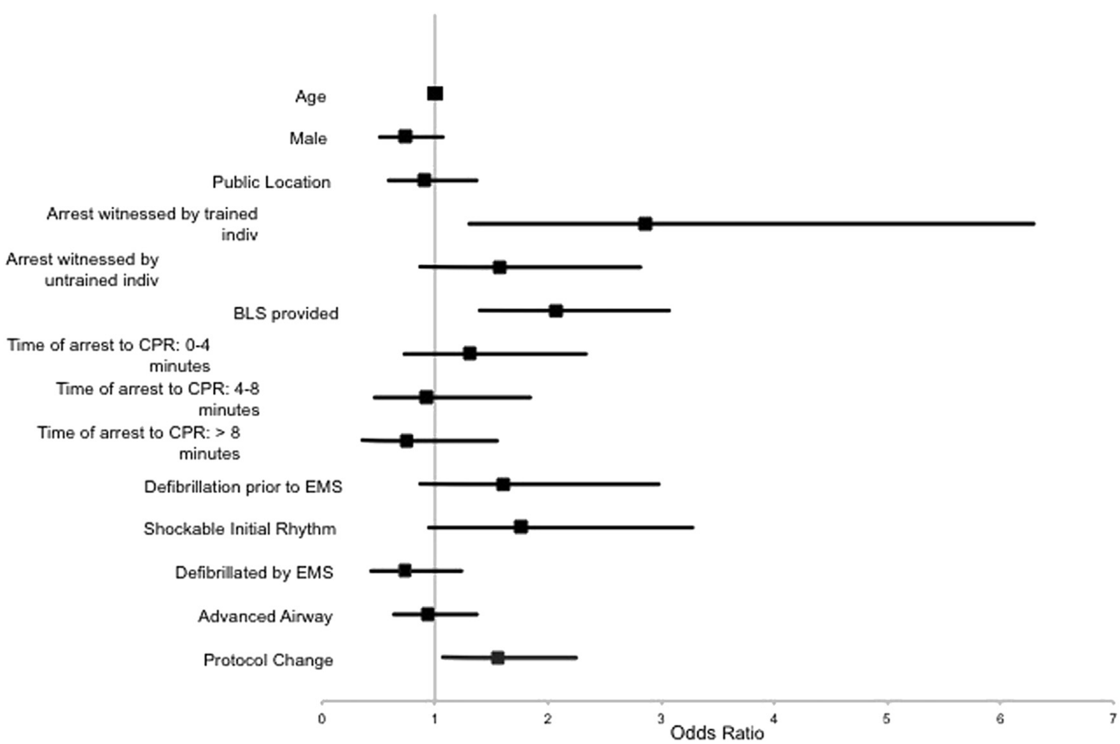

Figure 2. Odds ratio and confidence intervals for return of spontaneous circulation according to multiple logistic regression. BLS = basic life support; CPR = cardiopulmonary resuscitation; EMS = Emergency Medical Services.

very low rates of ROSC (3–-9%) compared with our patient population (32.4%), suggesting there are other inherent differences in the groups (17,21).

While our data show that the protocol change was independently associated with an increase in ROSC, our results do not specify why. Our main theory is that with the 30-min STI rule, the EMS crew is better able to provide consistent, high-quality CPR that is free of interruptions, thereby increasing the likelihood of ROSC. These results are congruent with studies that analyze the quality of CPR given at the arrest site vs. in transport (8–11). One such study found that pauses in compressions during transport—whether to give ALS or due to the simple nature of being in a moving vehicle—to be detrimental to maintaining effective circulation to vital organs (10). In line with the available literature, we also found that when a trained individual witnessed an arrest or BLS was available, there was an independent positive correlation with ROSC. This is not surprising, as these factors are well known to positively affect survival (2–7).

It is interesting to note that while the protocol change mandated spending 30 min on scene, and we found a significant increase in the scene time, the mean STI after the change was only 29 min 30 s. This means that half of the time, the crew spent < 30 min on scene. We do not interpret this as a failure of the protocol or presume that the ALS teams were not following the protocol. We actually did not expect all of the scene times to be ≥ 30 min because patients achieving ROSC are being transported at the time of ROSC. In other words, the ALS team is instructed to transport immediately upon ROSC, not to wait until the 30-min time point. The idea behind the 30-min scene time rule was to improve the quality of the resuscitation on scene for up to 30 min and then allow an option for TOR after 30 min. While we expected the scene time to increase, we would be concerned if all scene times were ≥ 30 min, as that would mean that none of the patients were achieving ROSC in < 30 min. Therefore, we do not interpret this as a limitation, as the care team is instructed to immediately transport once ROSC is achieved or if they believe they cannot carry out the resuscitation while remaining on scene.

Limitations

This study does have several limitations. First, it is a retrospective study. Much of the data for the cardiac arrest database is collected in real time via a computer runsheet by the treating ALS team, which is reassuring, but the database did have a significant number of missing data points and opportunities for bias. We were restricted by the variables available in the EMS runsheet, and would have liked to see additional options like chest compression fraction or the ability to determine whether the team followed the protocol appropriately. We are also limited in that this is a single EMS system, so we cannot assume that our experience would extrapolate to many EMS systems across the country.

Most importantly, we recognize that the use of ROSC as our primary outcome instead of survival to hospital discharge or neurologic outcome is a significant limitation. We were limited in that this EMS system transports patients to many different hospitals in the metropolitan area and not all were able or willing to provide survival or neurologic data. We appreciate that an increase in ROSC does not necessarily equate to improved neurologic outcome or survival, and that without survival or neurologic outcomes data, we cannot make any recommendations for the optimal scene time for EMS systems. We still believe, though, that these results are important to share. An appropriate future study would examine a subset of these patients with neurologic outcomes data, if they become available.

CONCLUSIONS

Our study found that with a protocol change mandating a 30-min STI in OHCA, our scene times increased as well as the rate of ROSC on arrival to the ED. Also, the protocol change was independently associated with improved ROSC in our patient population. Without neurologic outcomes data it is difficult to make recommendations on the most effective STI for OHCA. More studies are needed assessing the functional status of patients who have longer scene times after cardiac arrest.

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ARTICLE SUMMARY

1. Why is this topic important?

Rates of return of circulation and survival in out-of-hospital cardiac arrest are poor. Recent efforts have focused on investigating ways to improve positive outcomes after out-of-hospital cardiac arrest.

2. What does this study attempt to show?

This study investigates the change in the rate of return of spontaneous circulation after implementation of a mandatory 30-min scene time for emergency medical personnel.

3. What are the key findings?

Our mean scene time increased after the protocol change. Additionally, the rate of return of spontaneous circulation improved. Regression indicated the protocol change was an independent predictor of increased return of spontaneous circulation.

4. How is patient care impacted?

Return of spontaneous circulation does not necessarily equate with survival, but these findings should prompt further studies to determine if a longer scene time will improve chances of survival in out-of-hospital cardiac arrest.