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An Analysis of Continuous Chest Compression CPR for EMS Providers During Out of Hospital Cardiac Arrest

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Abstract

A significant amount of research has been done in an attempt to improve the outcomes of patients found in cardiac arrest outside the hospital. The American Heart Association has long advocated Advanced Cardiac Life Support (ACLS), a procedure that encompasses cycles of chest compressions with advanced airway maintenance and defibrillation. Recent evidence has suggested that these current guidelines are ineffective due to prolonged "hands off" time. New research suggests utilizing a technique known as continuous chest compression CPR that delays advanced airway management and instead focuses on defibrillation and continuous chest compressions. Across the country, research has demonstrated that when EMS providers utilize this technique and have support from the receiving hospital, survival to hospital discharge rates have increased from 4.7% (using standard ACLS) to 17.6% (with the new technique). The Newark (OH) Fire Department protocols were modified to implement continuous chest compression CPR for the care of patients in cardiac arrest. The present research analyzes quality improvement (QI) / quality assurance (QA) data from this fire department to determine how the change in protocol affected patient outcome. The results of this study suggest that patient outcome is not related to the type of cardiac arrest treatment provided by EMS.

An Analysis of Continuous Chest Compression CPR for EMS Providers During Out of Hospital Cardiac Arrest

Introduction

Sudden cardiac arrest (SCA)[1] is the number one cause of adult death in the United States (Bobrow & Clark, 2009). Previous research by Abella, Aufderheide, Eigel, Hickey, Longstreth, Nadkarni et al. (2008) indicates that approximately 330,000 people die annually from SCA and about half of these cases occur outside of the hospital. In the rare event that a victim survives to hospital discharge, it is unlikely that he or she will retain normal neurological function as a result of prolonged periods of hypoxia to the brain (Ewy, 2005a). Witnessed cardiac arrest with a shockable electrocardiogram (ECG) rhythm (pulseless ventricular tachycardia – VT, or ventricular fibrillation – VF) has the best chance for patient survival (Eisenberg, Hailstron & Bergner, 1981). A study of out of hospital cardiac arrest (OHCA) determined that in 2005, only 4.7% of victims with witnessed VF survived to normal neurological outcomes (Bobrow, Clark, Ewy, Chikani, Sanders, Berg et al., 2008). Despite the standardized treatment the American Heart Association (AHA) recommends for the care of a victim in cardiac arrest, low survival rates remain. This anomaly has led to a research initiative to improve outcomes and renovate these guidelines. Recent evidence has suggested that poor outcomes are the result of prolonged "hands off" time. Wik, Kramer-Johansen, Myklebust, Sorebo, Svensson, Fellows, and Steen (2005) found that patient survival was correlated with minimal interruptions in chest compressions.

The current AHA cardiopulmonary resuscitation (CPR) guidelines, known as Advanced Cardiac Life Support (ACLS) incorporate positive pressure ventilations, and early endotracheal intubation in addition to chest compressions and defibrillation (American Heart Association, 2005a, 2005b, 2005c). Research in the United States and Europe has demonstrated that a different technique called continuous chest compression CPR (CCC CPR), which focuses on continuous chest compressions and defibrillation, has been more successful in returning spontaneous circulation and decreasing patient mortality (Bobrow et al., 2008; Ewy, 2005a; Ewy, 2009b; Ewy, Kellum, & Bobrow, 2008c; Ewy, Kellum, & Bobrow, 2009d; Ewy, Zuercher, Hilwig, Sanders, Berg, Otto et al., 2007e; Kellum, Kennedy, Barney, Keilhaur, Bellino, Zuecher, & Ewy, 2008). Bobrow et al. (2008), demonstrated survival to hospital discharge rates as high as 17.6% for victims with witnessed VF after training Emergency Medical Services (EMS) responders in CCC CPR in Arizona. In Wisconsin, Kellum et al. (2008) found that rates of survival for victims of witnessed cardiac arrest with a shockable rhythm increased from 20% with standard AHA guidelines to 47% after CCC CPR was added to the EMS cardiac arrest protocol. Ewy et al. (2007e) reports an experiment in which swine were induced into cardiac arrest and treated with standard BLS CPR as well as CCC CPR. The group that was treated with standard AHA BLS bystander CPR before simulated EMS arrival survived 42% of the time; the group treated with CCC CPR before EMS arrival had a 70% survival rate. The high rates of survival that have been demonstrated with CCC CPR were the basis for the adoption of this protocol by the Newark Fire Department.

Ewy (2005a) demonstrated that the ACLS interventions focusing on advanced airway and respiratory care result in fatal consequences. He argues that “focusing on the ABCs” (A – maintain an open airway, B – give rescue breaths, C – begin chest compressions if no pulse) is an outdated standard of practice. Maintaining the airway typically results in repeated and unsuccessful endotracheal (ET) intubation attempts, inadvertently resulting in a significant amount of time elapsing without chest compressions (Ewy, 2009b).

Rescue breathing, which involves positive pressure ventilation, increases intrathoracic pressure by its very nature (Ewy, 2005a). The high pressure in the chest cavity decreases venous return and lowers perfusion pressure, the measure of how well oxygen is being circulated throughout the body. Performing chest compressions develops perfusion pressures in the heart and brain (Ewy, 2005a), preventing hypoxia to these vital organs. Maintaining high perfusion pressures is a major determinant of survival; ceasing chest compressions, even for a short period, significantly drops these pressures. According to studies cited by Ewy (2005a), high coronary and cerebral perfusion pressures are related to the return of spontaneous circulation. CCC CPR focuses on minimal “hands off” time to maintain high perfusion pressure.

The stress of a cardiac arrest may trigger EMS as well as in-hospital providers to overcompensate while providing rescue breaths. Previous research (Aufderheide, Sigurdsson, Pirrallo, Yannopolous, McKnite, von Briesen et al., 2004) demonstrated that during cardiac arrest, EMS providers give an average of 37 breaths per minute instead of the ACLS recommended 8-10 breaths per minute (American Heart Association, 2005a) with an advanced airway. Hyperventilation increases the already high intrathoracic pressure; thus decreasing cardiac output and lowering survival rates. Experiments with swine (Aufderheide et al., 2004) demonstrated that animals ventilated at a higher rate (20 and 30 breaths per minute) had lower perfusion pressures and were less likely to survive than those that were ventilated at a lower rate (12 breaths per minute). This study (Aufderheide et al., 2004) also followed thirteen patients who were ventilated at an average rate of 30 breaths per minute during cardiac arrest. The authors reported that none of these patients survived. The deleterious effects of all too common hyperventilation during standard ACLS CPR suggests that a method that eliminates positive pressure ventilation, such as CCC CPR, may enhance rates of survival.

The present AHA Basic Life Support (BLS) guidelines (American Heart Association, 2005a, 2005b) advocate performing two rescue breaths over a period of four seconds for victims of cardiac arrest without an advanced airway. Several studies have demonstrated that it may be impossible to perform this feat. Previous research by Assar, Chamberlain, Colquhoun, Donnely, Handley, Leaves, and Kern (2000), Heidenreich, Higdon, Kern, Sanders, Berg, Niebler et al. (2004), and Higdon, Heidenreich, Kern, Sanders, Berg, Hilwig et al. (2000) demonstrated that lay individuals, medical students, and paramedics take 16, 14, and ten seconds respectively to give two breaths. As a result, less time is spent doing chest compressions. The Higdon et al. (2000) study found that paramedics performing standard BLS CPR gave an average of 44 chest compressions per minute, whereas those performing CCC CPR gave an average of 88 chest compressions per minute. Similar trends were found with lay individuals (Assar et al., 2000) and first year medical students (Heidenreich et al., 2004). These studies, which have demonstrated that providing more chest compressions per minute (around a rate of 100 per minute) relates to better patient outcomes, encourages investigation in the effectiveness of CCC CPR.

Because positive pressure ventilation appears to do more harm than good while treating cardiac arrest, CCC CPR recommends passively oxygenating the victim, by inserting an oralpharyngeal airway and using a nonrebreather mask with 100% oxygen for three cycles of CCC CPR (figure 1). The argument is that victims of a recent arrest still retain oxygen in their blood, so the best option is to circulate this oxygen to organs instead of ventilating without performing adequate circulation. CCC CPR requires rescuers to perform three rounds of 200 chest compressions, ECG rhythm analysis, and shock (if indicated) before any advanced airway care or positive pressure ventilation is performed. After three cycles, standard ACLS protocols should be resumed (Bobrow & Clark, 2009; Ewy 2005a; Ewy et al., 2008c; Ewy et al., 2009d; Mell, 2008).

Several studies have been based on previous research by Weisfelt and Becker (2002). Their study breaks down cardiac arrest due to VF into three distinct physiological phases: the electrical phase, the circulatory phase, and the metabolic phase. The electrical phase lasts for the first four minutes after cardiac arrest. If an arrest is treated during this phase, the chances of survival are high because it can easily be treated with defibrillation. The availability of automated external defibrillators (AEDs) in public locations has drastically improved survival from OHCA (Ewy, 2009b). The rate of survival from SCA in Las Vegas casinos is about 74% if the patient is shocked within three minutes of the arrest. This phase lasts a short time period without intervention; however, it can be extended by performing immediate chest compressions, thus increasing chances of survival. Because EMS providers rarely witness cardiac arrest, better rates of survival have been documented when bystanders begin performing uninterrupted chest compressions immediately after an arrest (Abella et al., 2008).

The circulatory phase follows the electrical phase and lasts from minute four to minute ten (Weisfelt & Becker, 2002); treatment beginning in this phase can lead to survival, but survival rates are lower than if treated during the electrical phase. EMS typically arrives to the scene of a cardiac arrest during this phase; the best treatment they can provide is a series of uninterrupted chest compressions for about three minutes, followed by defibrillation (Ewy, 2008c). Immediate defibrillation during this phase makes resuscitation less likely (Ewy, 2005a).

CCC CPR requires EMS providers to perform a series of continuous chest compressions before performing any defibrillation or rhythm analysis.

Lastly, the metabolic phase begins after ten minutes of untreated cardiac arrest (Weisfelt & Becker, 2002). During this phase, irreversible damage is done to the body; treatment beginning after ten minutes rarely results in survival to hospital discharge, but further research is still necessary to determine if there is any chance of viability once a victim has entered this phase. The CCC CPR protocol (figure 1), allows paramedics to consider termination of efforts with a prolonged asystolic rhythm.

Because immediate CPR prevents a victim from progressing into the later stages of cardiac arrest, many agencies that have incorporated CCC CPR into their cardiac arrest protocol have also incorporated a community outreach program to increase the incidence of bystander initiated CPR before EMS arrival. The Arizona Department of Health Services (Arizona Department of Health Services, 2010; Bobrow, 2009) developed the SHARE (Save Hearts in Arizona Registry and Education) program, which attempts to increase survival rates from SCA by changing EMS protocols and encouraging bystander initiated CPR via the “Be a Lifesaver” program. This program gives the public access to free “hands only” CPR classes, online CPR training, and encourages early access to EMS (Ewy, 2005a). Over 68 EMS agencies and hospitals were involved in the SHARE program at the time of the Bobrow and Clark (2009) study. As a part of this initiative, EMS dispatchers in Tuscon provide callers with instructions for performing “hands only” CPR before EMS arrives. Other agencies that have incorporated CCC CPR into the EMS protocol have also developed programs in public education to increase the incidence of bystander CPR. In 2004, Rock and Walworth counties in Wisconsin (Kellum, et al.,

2008) and the city of Seattle, Washington (Ewy, 2005a) began requiring EMS dispatchers to give bystanders instructions for performing compression only CPR before EMS arrived.

This paper attempts to analyze the effectiveness of CCC CPR when it is adopted as an EMS cardiac arrest protocol in isolation from other changes in OHCA management. Earlier research performed by Ewy (2005a), has demonstrated that swine induced into cardiac arrest have similar survival rates when treated with CCC CPR (73%) and standard ACLS CPR (70%) before simulated advanced life support (ALS) arrival. This study raises questions about the actual effectiveness of CCC CPR in comparison to ACLS CPR.

The present study addresses limitations that have been prevalent in previous research on the implementation of CCC CPR into an EMS protocol. Earlier research on CCC CPR also included the implementation of community based initiatives, or other attempts to increase survival from OHCA. These additional initiatives may have contributed to the increased patient survival and these changes were erroneously attributed to CCC CPR (rather than the combination of changes). This paper attempts to determine if there is an increase in patient outcome by solely implementing CCC CPR into an EMS cardiac arrest protocol. The community in question did not have a public CPR education initiative, changes to the pre-arrival instructions provided by emergency dispatchers, or significant system changes in the emergency department management of these patients. CCC CPR was initiated by the fire department in an effort to improve patient outcome, thus an analysis of the outcome data allows an examination of the isolated implementation of CCC CPR into a cardiac arrest protocol. Previous research (Bobrow et al., 2008; Ewy, 2005a; Ewy et al., 2008c; Ewy et al., 2009d; Kellum et al., 2008; Nichol, Thomas, Callaway, Hedges, Powell, Aufderheide et al., 2008; Weisfeldt & Becker, 2002) has only measured patients with a witnessed shockable rhythm (VF or VT). However, with a decreasing proportion of cardiac arrests with VF as the first identified ECG rhythm (Weisfeldt & Becker, 2002), it is important to include all initial cardiac arrest ECG rhythms in researching a new protocol. It is also necessary to determine if the new protocol has any deleterious effects on those victims without a witnessed VF or VT ECG rhythm. The present research measures all cases in which resuscitation attempts were made.

Method

The present research compares Newark (OH) Fire Department (NFD) OHCA quality assurance (QA) / quality improvement (QI) data. NFD is a paid squad of firefighter/ paramedics who ran 7783 medical calls in 2009. Permission to publish deidentified patient data was granted by the institutional review board at Illinois Wesleyan University because it involves the analysis of existing data previously used for QA / QI purposes. EMS run reports (years 2005-2009) in which the chief complaint was cardiac arrest, those where providers indicated performing defibrillation, or those where providers reported performing chest compressions were compiled. These reports were reviewed (figure 2) for completeness and for inclusion criteria. Two EMS professionals reviewed these run reports, deidentified the data set, and determined cases that were applicable for the current project. Exclusion criteria were age (under 18 years), secondary cardiac arrest (result of trauma, known poisoning, or respiratory arrest), and not transported to the hospital (due to obvious signs of death or valid do not resuscitate (DNR) documentation available on EMS arrival). One record was excluded due to the lack of a narrative report describing the events of the call.

NFD paramedics used ACLS treatment protocols in 2005-2007; in 2008, a new medical director was hired. The department continued using traditional ACLS protocols, but each member of the department was personally retrained in airway management by the new medical director in small groups of three to five persons. In 2009 they were educated on the new cardiac arrest protocol, which incorporated CCC CPR (table 1). The years in which NFD paramedics used ACLS for cardiac arrest were used as a baseline in comparison to the implementation of CCC CPR.

The CCC CPR protocol begins with performing 200 continuous chest compressions at a rate of 100 compressions per minute (figure 1) while simultaneously beginning an intraosseous (IO) infusion device, administering Epinephrine IO, and passively oxygenating the victim. This first set of chest compressions is followed by rhythm analysis and shock if indicated, followed by 200 chest compressions before a pulse check or reanalysis of rhythm. Three more cycles of CCC CPR are to be performed before resuming standard ACLS treatment or considering intubation. The data were analyzed to determine if the implementation of CCC CPR into the EMS protocol would improve patient outcome after cardiac arrest.

This paper compares patient outcome to the type of CPR given by EMS, which was determined by the year (table 1). A negative outcome was defined as expiration in the receiving hospital (either in the emergency department or after being admitted), and a positive outcome included patients that were discharged or transferred out of the facility. In addition to comparing year with patient outcome, researchers also compared patient outcome to cases which bystanders initiated CPR, arrests witnessed by bystanders, and arrests witnessed by EMS professionals. These variables are described below.

Year: This variable compared years 2005-2008, using standard ACLS, with 2009, when the protocol included CCC CPR

Bystander CPR: Delineated cases in which bystanders performed CPR before EMS arrived, as documented in the EMS run report

Bystander Witnessed: Delineated cases in which bystanders mentioned that they saw the victim suddenly collapse, as documented in the EMS run report

EMS Witnessed: Delineated cases in which EMS providers documented witnessing the victim suddenly collapse during the call

Due to the outcome variable being dichotomous, an odds ratio was used to determine if victims who received care in 2009 (CCC CPR) were more likely to survive than victims treated during 2005-2008 (standard ACLS care). Patient demographic and call information (table 2) were compared to ensure that there were no statistical differences between the two groups. Subanalyses were performed in with an ordinal regression in SPSS version 17 (SPSS, Inc, Chicago, IL).

Results

NFD treated 209 cardiac arrests during 2005-2009. 137 cases met the criteria for inclusion and 133 cases had information complete with patient outcome data from the receiving hospital. Of these cases, 34 were from 2009, when CCC CPR was incorporated into the cardiac arrest protocol and 99 were from 2005-2008, when standard ACLS was used for cardiac arrest management. Researchers compared the complete cases from 2009 to the complete cases from 2005-2008.

A comparison was made between patient demographic and call information to ensure that there was no statistical difference between the two groups. An independent samples t-test was run for the continuous variables: age, time from dispatch to scene, and time from scene to arrival at the hospital. A chi square test was run for the dichotomous variables, initial rhythm and sex. Both tests revealed no significant differences between the two groups (table 2).

Among the 34 cardiac arrests that were treated by NFD in 2009, 17.6% (n=6) of victims had a positive outcome, whereas 14.1% (n=14) of victims had a positive outcome during 2005-2008 (table 3). Researchers used an odds ratio with a 95% confidence interval (table 4) to determine the differences between these groups. It was not statistically more likely for groups treated in 2009 to have a better outcome than those treated in 2005-2008 (OR, 1.301; 95% CI, 0.4565-3.7082). This odds ratio was followed by subanalyses using an ordinal regression (table 5) in SPSS version 17 (SPSS, Inc, Chicago, IL). A Wald test determined that there were no significant differences in any of the measured variables when compared to patient outcome.

Discussion

The results of this study suggest that there was no difference in patient outcome based on the type of CPR performed by EMS providers. The lack of difference in patient outcome between each category warrants further analysis. It may be due to differences in public health initiatives, different definitions of patient outcome, or low statistical power present in this study.

Determining the differences between the present study and previous CCC CPR studies plays an important role in understanding the effectiveness of CCC CPR. Unlike most previous research on CCC CPR, the present study analyzed only one manipulated variable in conjunction to patient outcome. The only change that Newark, Ohio received in 2009 was the addition of a new universal cardiac arrest protocol (Mell, 2008) for prehospital care of SCA. Previous research (Bobrow et al., 2008; Kellum et al., 2008) has implemented “bundles” of changes for increasing survival rates from SCA, which include a new protocol, other public health initiatives, (Bobrow et al., 2008; Kellum et al., 2008; Ewy, 2005a) and access to hospitals with more resources (Bobrow et al., 2008; Ewy, 2005a; Kellum et al., 2008). The lack of other public health and hospital initiatives for improving rates of survival from SCA may be partly responsible for the disparity between previous research and the present study. The community in which the present study is based had only implemented the new CCC CPR EMS protocol and had not yet implemented other hospital or community health initiatives (e. g., a 24 hour cardiac catheterization laboratory, dispatcher given instructions for compression only CPR). Previous research has incorporated community education for bystander initiated CPR before EMS arrival along with the implementation of CCC CPR into the cardiac arrest protocol (Arizona Department of Health Services, 2010; Ewy, 2005a; Kellum et al., 2008). In conjunction with the CCC CPR protocol, the Arizona Department of Public Health began a public CPR education program. Citizens have access to education about how and when to perform CPR (Arizona Department of Health Services, 2010; Ewy, 2005a). Previous research has indicated that eliminating the mouth-to-mouth part of standard CPR increases the likelihood of bystander CPR during an emergency (Heidenreich et al., 2004). Even without previous training, EMS dispatchers can give “hands only” CPR instructions over the phone to increase the likelihood of bystander initiated CPR. EMS dispatchers in Tuscon, AZ (Ewy, 2005a), Rock and Walworth counties in Wisconsin (Kellum et al., 2008), and Seattle (Ewy, 2005a), gave compression only CPR instructions over the phone and found that it increases patient outcome after OHCA. It is probable that increasing the likelihood of bystander initiated CPR will improve patient outcomes, but further research is necessary. Studies cited by Abella et al. (2008), demonstrated survival rates from SCA as high as 21% with bystander-initiated CPR.

Another difference between previous studies and the present study is the wide variety of definitions of patient outcome. As a retrospective study, the present authors were only able to tabulate the outcome from information from the receiving hospital. This hospital transferred 75% (15 out of 20 for all five years combined) of its patients out of the hospital for post arrest cardiac care as it did not have a 24 hour cardiac catheterization laboratory at the time of the data collection. Previous research had more resources and more opportunities to measure patient outcome; for example, previous measures of patient outcome included survival to hospital discharge (Bobrow et al., 2008; Bobrow & Clark, 2009), return of spontaneous circulation (Bobrow et al., 2008; Ewy et al., 2007e), survival to hospital admission (Bobrow et al., 2008), survival to neurologically normal outcomes for those with witnessed VF or VT (Ewy, 2008c; Kellum et al., 2008; Ewy et al., 2007e), VF survival to hospital discharge (Ewy et al., 2009d; Kellum et al., 2008; Bobrow et al., 2008; Bobrow & Clark, 2009), survival to discharge for patients with a witnessed collapse and shockable rhythm (Ewy et al., 2009d), those which had a perfusing rhythm after the first shock (Ewy et al., 2007e), and 24 hour survival (Ewy et al., 2007e). The present study encompassed all cases where resuscitation was attempted. One rationale was that this wide net would capture more realistic survival rates.

Another difference between the present study and previous research is the broadness of the protocol used by NFD. The protocol (Mell, 2008) is a universal cardiac arrest protocol that is indicated for all patients who are in cardiac arrest with an apparent cardiac etiology. Previous research (Bobrow et al., 2008; Ewy, 2005a; Ewy et al., 2008c; Ewy et al., 2009d; Kellum et al., 2008; Nichol, Thomas, Callaway, Hedges, Powell, Aufderheide et al., 2008; Weisfeldt & Becker, 2002) has only measured patients with a witnessed shockable rhythm (VF or VT). However, an aim of the present study was to determine the effectiveness of the universal protocol as treatment for those in primary cardiac arrest. It is also important clinically to ensure that the addition of the new protocol is not deleterious for patients in cardiac arrest with an ECG rhythm other than VF or VT. Since the population of victims of cardiac arrest with a shockable rhythm is decreasing (Weisfeldt & Becker, 2002), future research should determine how a new protocol effects all victims of cardiac arrest despite ECG rhythm.

The present research found no significant difference in patient survival based on the type of CPR (standard ACLS or CCC CPR) provided by EMS professionals. The lack of a difference between the two may be related to the low statistical power of the present study; however, it demonstrates that future research on the effectiveness of CCC CPR in isolation is needed. The change in protocol may not be the key link in the chain of survival from SCA; rather, increased survival rates may be attributed to other factors (such as changes in procedure at the receiving hospital or other public health initiatives). The results of this study suggest that CCC CPR is not harmful for the care of SCA and may be a viable option. In fact, it may be a worthwhile protocol for EMS providers as it is simpler and more cost effective. It does not require positive pressure ventilation or intubation, which can be difficult to accomplish in one attempt. It also replaces insertion of an intravenous (IV) catheter with an IO infusion device, a more rapid and effective method of fluid and medication administration than IV insertion.

Several limitations to this study must be addressed. Two EMS providers judged cases that were eligible for inclusion in the study. Criteria for exclusion included age (under 18 years), not transported to the hospital (e. g., rigor mortis, lividity, or presence of a valid DNR at the scene), and a secondary arrest (e. g., from a respiratory origin, known poisoning, or trauma). As it is difficult in the field to determine the etiology of an unwitnessed arrest, there is a possibility that some of the cases included were not primarily of a cardiac origin. Another limitation is that the present paper utilized data from one town in the Midwestern United States; thus, a small data set (n=133) may have altered the statistical analyses. The control group was composed from four years of data (n=99), while the variable group was composed from one year of data (n=34). This may have had an effect on the statistical analyses as it can be difficult to detect a difference with a small number of subjects. Despite efforts to obtain patient outcome data for all cardiac arrest cases treated by the Newark Fire Department, researchers were unable to collect all of this information (n=4); however there is no reason to suspect that it represents a systematic bias. Previous research also measured a “compliance rate” to the new protocol (Bobrow et al., 2008) using specific criteria. The present study determined that 88.2% of the cases paramedics performed the majority of the protocol correctly (e. g., performed 200 initial chest compressions, began an IO infusion device, and delayed intubation); however, there was no way to accurately determine if paramedics performed either the CCC CPR or standard ACLS in the correct manner. A final limitation of this study is that researchers were unable to gather information on patients that were transferred out of the receiving hospital. Therefore, all patients stable enough to leave the facility, including those that were transferred to hospice care, were placed in the positive patient outcome category.

The findings of the present study suggest that when CCC CPR is integrated into an EMS protocol, patients are no more or less likely to survive than if they had been treated with standard ACLS cardiac arrest procedures. The lack of significance found with the integration of CCC CPR into the EMS protocol in Newark, Ohio warrants replication as most research on this topic has found increases in patient survival. Future research could compare communities that only integrate CCC CPR into the protocol and communities that incorporate the protocol along with dispatch given CPR instructions for bystanders.

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Footnotes

1. Thank you to the Newark Fire Department paramedics, Licking Memorial Hospital, Kathryn Baldeschwiler, and Mike White for their contributions to this paper.

Figures and Tables

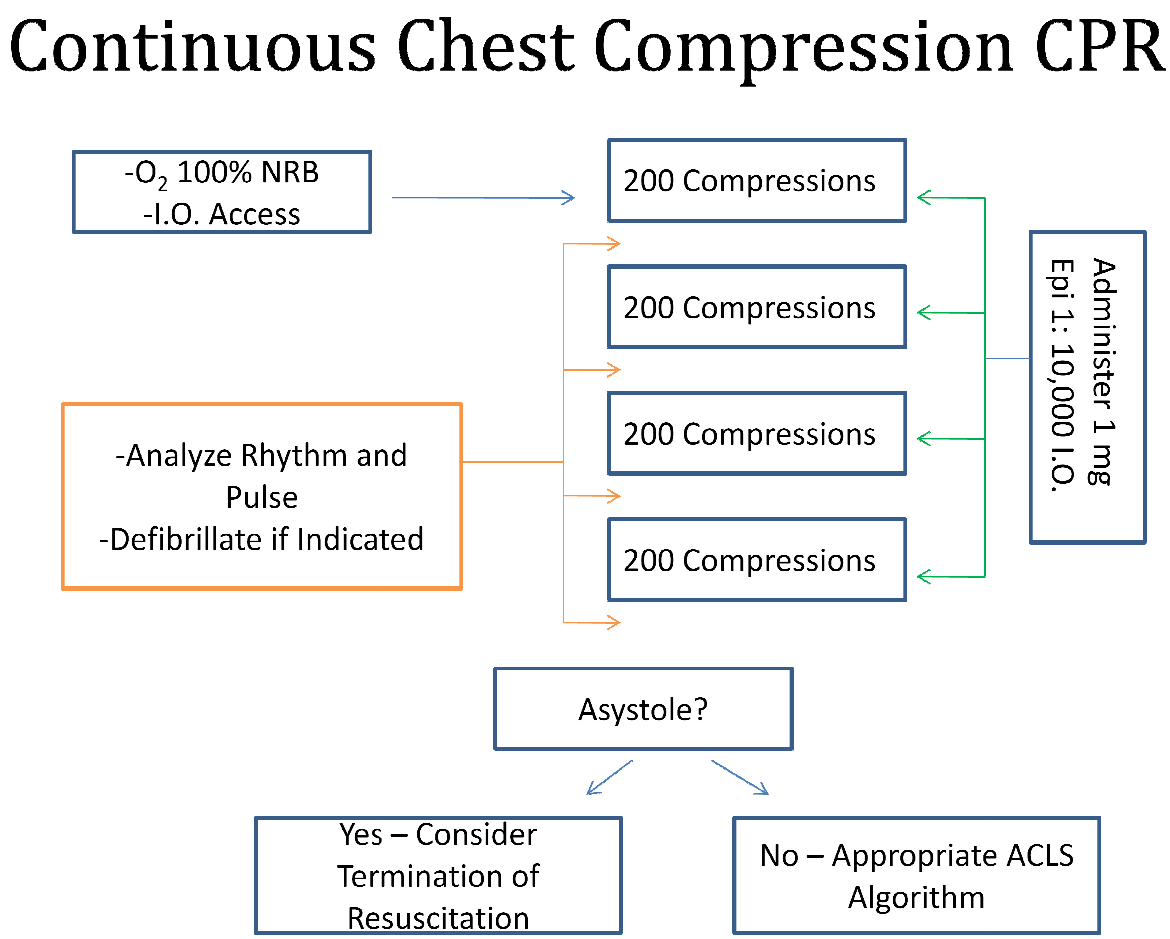

Figure 1. Newark Fire Department CCC CPR Cardiac Arrest Universal Algorithm, used in 2009 (Mell, 2008)

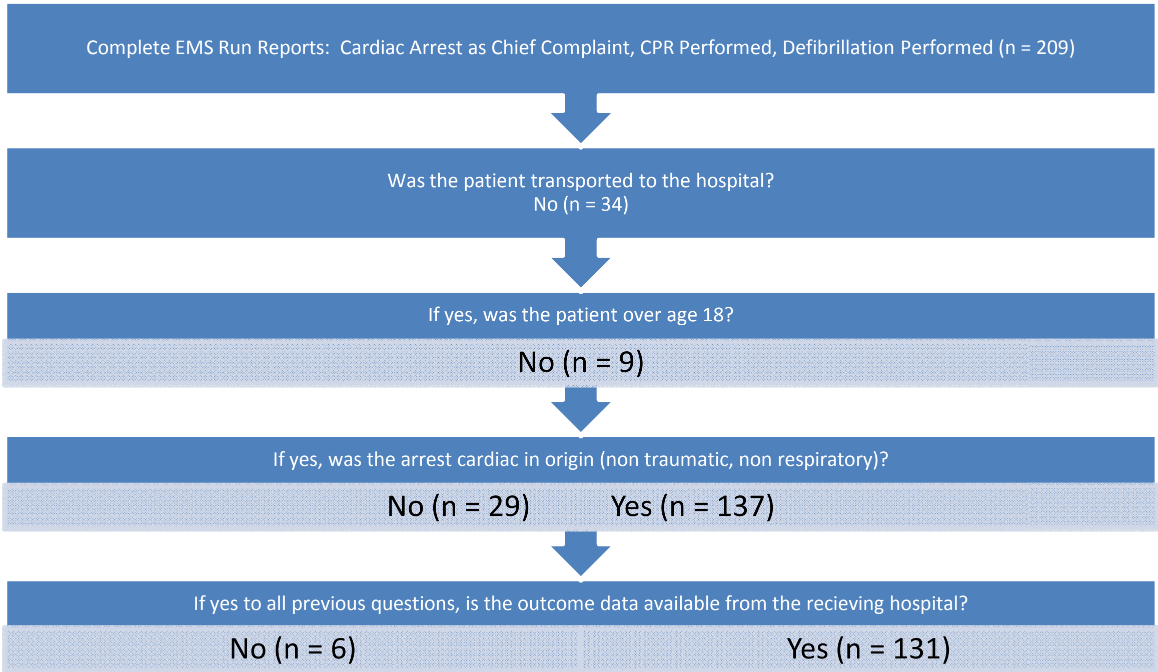

Figure 2. An overview of the process of determining cases eligible for inclusion in the study. Cases that were considered include those which the patient was transported to the hospital, the patient was over age 18, and the arrest appeared cardiac in origin.

Year	Type of CPR
2005	Standard ACLS
2006	Standard ACLS
2007	Standard ACLS
2008	Standard ACLS with Small Group Retraining by New Medical Director
2009	CCC CPR with Large Group Training

Table 1. Cardiac arrest procedure Newark Fire Department (NFD) followed by year

	Before (2005-2008)	After (2009)	*p*
Mean Age	65.2 years (SD 15.8)	61.6 years (SD 29.2)	.3678
Sex	60.6% male (n=60)	61.8% male (n=21)	.950
Mean Time to Scene	5.8 minutes (SD 2.5)	5.2 minutes (SD 2.4)	.2249
Mean Time to Hospital	23.3 minutes (SD 6.0)	21.5 minutes (SD 6.7)	.1455
Initial VF / VT	35.3% (n=35)	32.4% (n=11)	.750

Table 2. Patient demographic and call information separated by year of protocol. The groups were not statistically different from one another.

	Expired at Hospital	Discharged / Transferred from Hospital
2005	n=19	n=1
2006	n=23	n=4
2007	n=23	n=3
2008	n=20	n=6
2009	n=28	n=6

Table 3. Patients who expired included those who did so in the ED and those who expired after admission to the hospital. Across the years, 15.0% of victims survived to discharge or were transferred out of the receiving hospital.

	Before (2005-2008)	After (2009)	Odds Ratio (95% CI*)
Positive Patient Outcome	14/99 (14.1%)	6/34 (17.6%)	1.301 (0.4565-3.7082)

Table 4. Odds ratio for patient outcome in the before and after groups. It cannot be determined with 95% confidence that patients were more likely to survive in 2009 than in 2005-2008.
*CI = Confidence Interval

Variable x Patient Outcome	Estimate	SE	Wald	df	*p*
Year (2005-2008 and 2009)	0.056	0.505	0.012	1	.911
EMS Witnessed (Yes / No)	-0.960	0.941	1.041	1	.308
Bystander Witnessed (Yes / No)	-0.368	0.449	0.671	1	.413
Bystander Initiated CPR (Yes / No)	-0.324	0.454	0.512	1	.474

Table 5. An ordinal regression was used in SPSS version 17 (SPSS, Inc, Chicago, IL) to perform subanalyses. A Wald test demonstrated that there were no significant findings for any of the above variables when compared to patient outcome.