Chest Compression–Only CPR by Lay Rescuers and Survival From Out-of-Hospital Cardiac Arrest

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Context Chest compression–only bystander cardiopulmonary resuscitation (CPR) may be as effective as conventional CPR with rescue breathing for out-of-hospital cardiac arrest.

Objective To investigate the survival of patients with out-of-hospital cardiac arrest using compression-only CPR (COCPR) compared with conventional CPR.

Design, Setting, and Patients A 5-year prospective observational cohort study of survival in patients at least 18 years old with out-of-hospital cardiac arrest between January 1, 2005, and December 31, 2009, in Arizona. The relationship between layperson bystander CPR and survival to hospital discharge was evaluated using multivariable logistic regression.

Main Outcome Measure Survival to hospital discharge.

Results Among 5272 adults with out-of-hospital cardiac arrest of cardiac etiology not observed by responding emergency medical personnel, 779 were excluded because bystander CPR was provided by a health care professional or the arrest occurred in a medical facility. A total of 4415 met all inclusion criteria for analysis, including 2900 who received no bystander CPR, 666 who received conventional CPR, and 849 who received COCPR. Rates of survival to hospital discharge were 5.2% (95% confidence interval [CI], 4.4%-6.0%) for the no bystander CPR group, 7.8% (95% CI, 5.8%-9.8%) for conventional CPR, and 13.3% (95% CI, 11.0%-15.6%) for COCPR. The adjusted odds ratio (AOR) for survival for conventional CPR vs no CPR was 0.99 (95% CI, 0.69-1.43), for COCPR vs no CPR, 1.59 (95% CI, 1.18-2.13), and for COCPR vs conventional CPR, 1.60 (95% CI, 1.08-2.35). From 2005 to 2009, lay rescuer CPR increased from 28.2% (95% CI, 24.6%-31.8%) to 39.9% (95% CI, 36.8%-42.9%; $P<.001$); the proportion of CPR that was COCPR increased from 19.6% (95% CI, 13.6%-25.7%) to 75.9% (95% CI, 71.7%-80.1%; $P<.001$). Overall survival increased from 3.7% (95% CI, 2.2%-5.2%) to 9.8% (95% CI, 8.0%-11.6%; $P<.001$).

Conclusion Among patients with out-of-hospital cardiac arrest, layperson compression-only CPR was associated with increased survival compared with conventional CPR and no bystander CPR in this setting with public endorsement of chest compression–only CPR.

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Out-of-hospital cardiac arrest is a major public health problem, affecting approximately 300 000 individuals in the United States annually.[1] Although survival rates vary considerably, overall survival is generally less than 10% among those in whom resuscitation is attempted.[2] The provision of bystander cardiopulmonary resuscitation (CPR) significantly improves outcome[3] but is generally performed in less than 30% of cases.[2,4]

In 2005, because our evaluation of out-of-hospital cardiac arrest in Arizona revealed dismal outcomes, we established a statewide program aimed at improving survival. These efforts included changes in the approach to the care provided by both bystanders and emergency medical services (EMS) personnel[5] and were based on the increasing evidence in favor of minimizing interruptions in chest compressions during CPR.[6-10] This led to alterations in the resuscitative care provided by EMS personnel, termed *minimally interrupted cardiac resuscitation* (MICR).[11,12] Simul-

See also p 1493 and Patient Page.

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Box. Intervention: Chest Compression–Only Cardiopulmonary Resuscitation Campaign in Arizona

- Web site (http://www.azshare.gov)
- Brief online video training
- In-person, free training in many settings and locations throughout the state (primarily sponsored by fire departments)
- Free training kits sent to schools (n=1816) in Arizona with 6th through 12th grades (students were encouraged to teach family members)
- Public service announcements made by the governor and local sports celebrities
- Inserts mailed in utility bills
- Tables set up at health and safety fairs by Boy Scouts, fire departments, schools, etc
- Newspaper articles and editorials
- Training video looped on public-access cable channels
- Summer youth classes taught by youth corps volunteers
- Local radio spots and interviews
- Special features on local and national television
- Frequent e-mail updates distributed to stakeholders

taneously, we launched a statewide, multifaceted effort to encourage bystanders to use compression-only CPR (COCPR) because this approach is easier to teach, learn, remember, and perform than conventional CPR.[13]

In this study, we evaluated whether intentional, widespread public endorsement of COCPR for adult sudden cardiac arrest would be associated with an increased likelihood that lay rescuers would perform CPR and an increased likelihood of survival to hospital discharge compared with no bystander CPR and conventional CPR.

METHODS

Arizona has 6.6 million residents and comprises 15 counties with demographics varying from urban to wilderness areas.[14] In 2005, 30 EMS agencies statewide participated in the state-sponsored quality improvement program for out-of-hospital cardiac arrest: the Save Hearts in Arizona Registry and Education (SHARE) program.[5,15] Participation increased each year of the study, and by 2009, 90 agencies (serving approximately 80% of the population) had joined SHARE. During the time period of this study, Arizona did not have a structured 911 dispatcher–assisted CPR program.

Because out-of-hospital cardiac arrest has been designated a major public health problem in Arizona and the goal of this program is quality improvement, the data collected were exempt from the Health Insurance Portability and Accountability Act (HIPAA). Permission to publish the deidentified data was obtained from the Arizona Department of Health Services human subjects review board and the University of Arizona institutional review board.

Data Collection and Definitions

This prospective, observational cohort analysis included patients who experienced out-of-hospital cardiac arrest in Arizona between January 1, 2005, and December 31, 2009. The study population comprised all adults (age ≥18 years) with an out-of-hospital cardiac arrest of presumed cardiac origin that was not witnessed by EMS personnel. The arrest was presumed to be of cardiac origin unless it was known to be caused by trauma, drowning, drug overdose, or asphyxia.[16,17] Patients with obvious evidence of death or those with do-not-resuscitate orders were excluded.

Data were collected prospectively and entered into an Utstein-style database.[16] Data elements included sex, age, location of arrest, whether arrest was bystander-witnessed, presumed etiology of arrest, EMS dispatch-to-scene-arrival ("response") interval, initial prehospital electrocardiographic (ECG) rhythm, whether bystander CPR was provided, type of bystander CPR (COCPR vs conventional), type of EMS protocol (MICR vs conventional BLS/ACLS [basic life support/advanced cardiac life support]), whether the patient received therapeutic hypothermia, survival to hospital discharge, and neurologic status.

Since a core question of this effort is related to the type of CPR provided, EMS personnel received special training and a documentation aid on how to code bystander CPR (available at http://www.azshare.gov). This training included instruction in documenting the person performing CPR as well as the type of CPR performed by bystanders. If the method of bystander resuscitation was not evident, EMS personnel were instructed to ask bystanders whether ventilations had been performed during CPR. For this analysis, because we were specifically interested in "true" layperson CPR, we excluded cases in which CPR was performed by bystanders with formal medical training (whether on or off duty). However, to assess the possibility of ascertainment bias, we compared the proportion of COCPR vs conventional CPR over time performed by lay bystanders and by bystanders with formal medical training. All cardiac arrests occurring in medical facilities were excluded.

Intervention

The SHARE program initiated a multifaceted, statewide public COCPR education campaign in 2005. The effort included multiple approaches to training and information dissemination (Box). We estimate that at least 30 000 people have been directly trained in the COCPR technique and that more than 500 000 were exposed to at least 1 COCPR media forum.

In March 2008, the American Heart Association released an advisory statement supporting Hands-Only CPR,[13] which was widely publicized in Arizona as an additional aspect of the ongoing effort.

Main Outcome Measures

The primary outcome measure was survival to hospital discharge, determined by review of hospital records. Final outcomes were obtained through hospitals and the Office of Vital Statistics at the Arizona Department of Health Services. Cerebral Performance Category (CPC) scores were assigned based on neurologic status at hospital discharge. The 5 CPC categories are good cerebral performance, moderate cerebral disability, severe cerebral disability, coma or vegetative state, and death.[16] Secondary measures were the frequency and type of bystander CPR provided. Predetermined subgroups for additional analyses were patients with a witnessed collapse and patients with a shockable rhythm on EMS arrival.

Statistical Analysis

Proportions were calculated for categorical data, whereas mean and standard deviation, or median and interquartile range (IQR), as appropriate, were calculated for continuous data. Statistical significance for categorical data was assessed using Fisher exact test or χ^2. Temporal trends for categorical data were assessed using a modified Wilcoxon signed rank test for trends across ordered groups (by year) if Fisher exact test or χ^2 were significant.

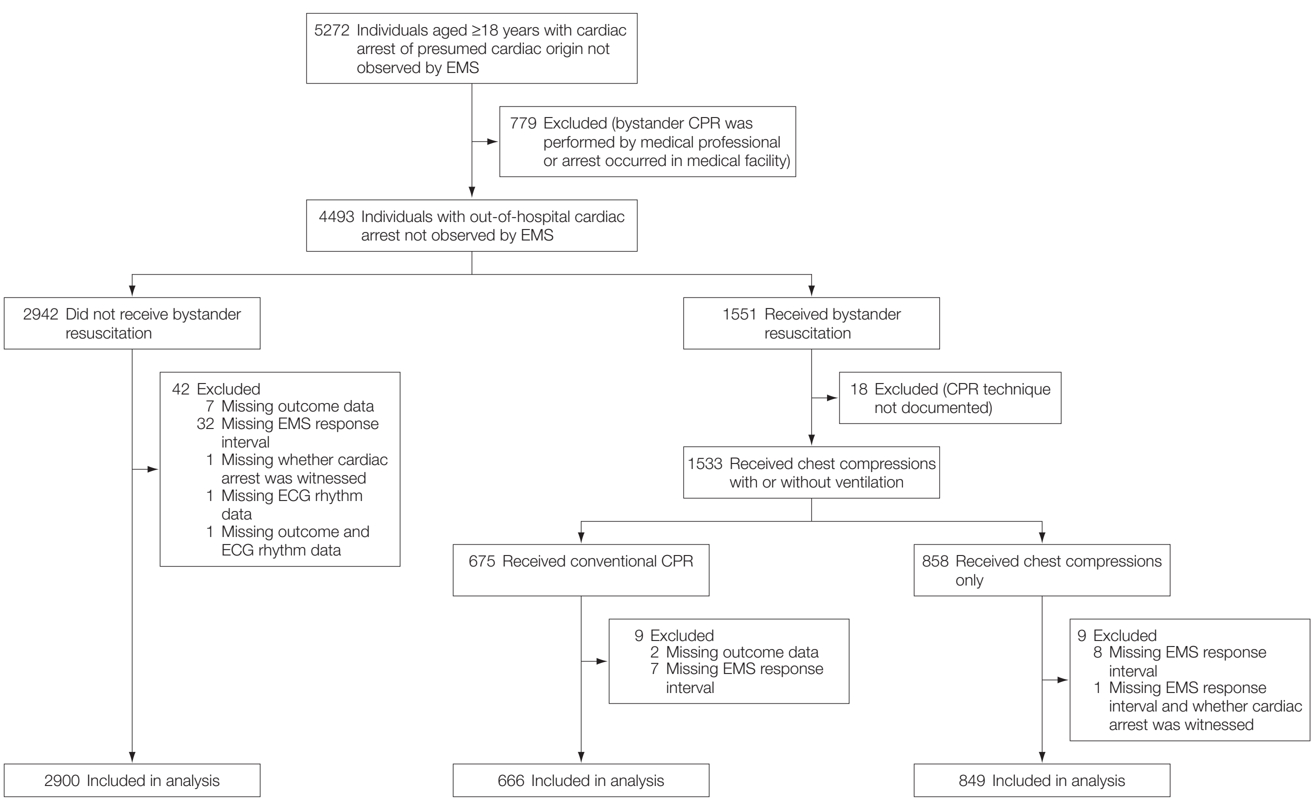
Multivariable logistic regression was used to model the association between CPR type (no CPR, conventional CPR, COCPR) with the probability of survival. The following covariates were considered for model inclusion: age, sex, witnessed arrest, shockable rhythm, bystander CPR provision and type, location of arrest, EMS response interval, EMS provision of MICR vs conventional BLS/ACLS, use of postarrest therapeutic hypothermia, and year. Continuous variables were assessed for linearity in the logit scale using quantiles, lowess smoothing, and fractional polynomials. Nonlinear covariates were categorized using cutpoints chosen to maximize model fit. Goodness of fit and the area under the receiver operator characteristic curve (ROC) were calculated to determine model fit and discrimination. The value of ρ was calculated for survival to hospital discharge among EMS systems and generalized estimating equations (GEEs) were used to determine the effect of clustering by EMS agency on survival.

Statistical significance was set a priori at $\alpha \leq .05$ (2-tailed). All statistical analyses were performed using Stata version 11.1 (StataCorp, College Station, Texas).

RESULTS

During the study period, 5272 adult out-of-hospital cardiac arrests of presumed cardiac etiology and not witnessed by EMS were reported. A total of 779 cases were excluded because bystander CPR was administered by a medical professional or the cardiac arrest occurred in a medical facility. A total of 78 cases were excluded because of missing data (1.7% of cases meeting inclusion criteria): 10 cases with missing outcome data, 2 cases missing data on whether cardiac arrest was witnessed by a bystander, 18 cases

Figure. Study Population Profile



EMS indicates emergency medical services; CPR, cardiopulmonary resuscitation; ECG, electrocardiographic.

without type of bystander CPR documented, 1 case with missing ECG rhythm data, and 47 cases with missing EMS response interval data. The final number of cases for analysis was 4415 (FIGURE).

TABLE 1 shows the demographic and clinical characteristics of the study population. The majority of arrests occurred in men (66.8%), and the mean (SD) age for all arrests was 65.3 (15.2) years (median age, 66 years). The cardiac arrest was witnessed in 45.1% of cases and a lay bystander performed CPR in 34.3%. Overall, 15.1% of patients received conventional bystander CPR and 19.2% received COCPR. Overall survival was 7.1%.

TABLE 2 shows the annual rates of bystander CPR and survival. The annual rate for lay rescuers providing any type of bystander CPR increased significantly over time, from 28.2% in 2005 to 39.9% in 2009 (χ^2 $P<.001$; test for trend, $P<.001$). Among patients who received bystander CPR, the proportion with COCPR increased significantly over time, from 19.6% in 2005 to 75.9% in 2009 (χ^2 $P<.001$; test for trend, $P<.001$). Overall survival also increased significantly over time: from 3.7% in 2005 to 9.8% in 2009 (χ^2 $P<.001$; test for trend, $P<.001$). Of 913 cases for which a medical professional provided bystander CPR, 71 received COCPR (7.8%; 95% confidence interval [CI], 6.0%-9.5%), whereas of 2019 cases for which a lay bystander provided CPR, 1086 received COCPR (53.8%; 95% CI, 51.6%-56.0%).

Multivariable logistic regression showed that COCPR was associated with improved odds of survival compared with no bystander CPR (odds ratio [OR], 1.59; 95% CI, 1.18-2.13) or conventional CPR (OR, 1.60; 95% CI, 1.08-2.35) after controlling for the following variables: witnessed arrest, shockable rhythm, EMS response interval, age, sex, location of arrest, provision of MICR by EMS personnel, and use of therapeutic hypothermia. TABLE 3 shows the crude and adjusted ORs for survival for all the variables in the final model. The goodness-of-fit test indicated adequate fit ($P=.98$) and the area under the ROC curve (0.854) indicated good model discrimination.

For out-of-hospital cardiac arrests that were witnessed by a lay bystander and had a shockable rhythm on EMS arrival (n=1017), survival was 17.6% in the no CPR group (reference group), 17.7% for conventional CPR (crude OR, 1.01; 95% CI, 0.68-1.52), and 33.7% for COCPR (crude OR, 2.39; 95% CI, 1.70-3.35). The adjusted ORs for survival (adjusted for all variables in the main

Table 1. Demographic Features, Clinical Characteristics, and Outcomes of Study Population According to Type of Bystander CPR

	All Out-of-Hospital Cardiac Arrest	Type of Lay Bystander CPR		
		None	Conventional	COCPR
Total, No. (%)	4415 (100)	2900 (65.7)	666 (15.1)	849 (19.2)
Age, mean (SD), y	65.3 (15.2)	66.2 (15.1)	63.8 (15.2)	63.1 (15.1)
Male sex, No. (%)	2951 (66.8)	1915 (66.0)	458 (68.8)	578 (68.1)
Witnessed arrest, No. (%)	1992 (45.1)	1177 (40.6)	388 (58.3)	427 (50.3)
Shockable rhythm (VF/VT) on arrival by EMS, No. (%)	1463 (33.1)	800 (27.6)	297 (44.6)	366 (43.1)
EMS resuscitation protocol used, No. (%)				
MICR	1726 (39.1)	1085 (37.4)	172 (25.8)	469 (55.2)
BLS/ACLS	2689 (60.9)	1815 (62.6)	494 (74.2)	380 (44.8)
Location of arrest, No. (%)				
Home/residential setting	3591 (81.3)	2517 (86.8)	474 (71.2)	600 (70.7)
Public setting	824 (18.7)	383 (13.2)	192 (28.8)	249 (29.3)
EMS response interval, median (IQR), min	5 (4-7)	5 (4-7)	5 (4-7)	5 (4-6)
Use of in-hospital therapeutic hypothermia, No. (%)	78 (1.8)	39 (1.3)	12 (1.8)	27 (3.2)
Year of arrest, No. (%)				
2005	596 (13.5)	428 (14.8)	135 (20.3)	33 (3.9)
2006	954 (21.6)	643 (22.2)	166 (24.9)	145 (17.1)
2007	845 (19.1)	571 (19.7)	144 (21.6)	130 (15.3)
2008	1009 (22.9)	650 (22.4)	124 (18.6)	235 (27.7)
2009	1011 (22.9)	608 (21.0)	97 (14.6)	306 (36.0)
Survival to hospital discharge, No. (%)	315 (7.1)	150 (5.2)	52 (7.8)	113 (13.3)
Neurologic outcome (CPC score), No. (%)				
1	138 (3.2)	60 (2.1)	25 (3.8)	53 (6.5)
2	44 (1.0)	26 (0.9)	9 (1.4)	8 (1.0)
3	24 (0.6)	9 (0.3)	2 (0.3)	13 (1.6)
4	11 (0.3)	7 (0.3)	1 (0.2)	3 (1.4)
5	4100 (95)	2750 (96.4)	614 (94.3)	736 (90.5)

Abbreviations: BLS/ACLS, basic life support/advanced cardiac life support; CI, confidence interval; COCPR, compression-only CPR; CPC, Cerebral Performance Category; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; IQR, interquartile range; MICR, minimally interrupted cardiac resuscitation (performed by EMS personnel); VF/VT, ventricular fibrillation/ventricular tachycardia.

Table 2. Annual Lay Bystander CPR Rates and Out-of-Hospital Cardiac Arrest Survival, 2005-2009[a]

	2005	2006	2007	2008	2009	Total
Cardiac arrest survival overall[b]	(n = 596)	(n = 954)	(n = 845)	(n = 1009)	(n = 1011)	(N = 4415)
No.	22	69	58	67	99	315
% (95% CI)	3.7 (2.2-5.2)	7.2 (5.6-8.9)	6.7 (5.2-8.6)	6.6 (5.1-8.2)	9.8 (8.0-11.6)	7.1 (6.4-7.9)
Survival from witnessed arrest with VF/VT[b]	(n = 130)	(n = 224)	(n = 224)	(n = 209)	(n = 230)	(n = 1017)
No.	14	50	42	47	70	224
% (95% CI)	10.8 (5.4-16.2)	22.3 (16.8-27.8)	18.8 (13.6-23.9)	22.5 (16.8-28.2)	30.4 (24.4-36.4)	21.9 (19.4-24.5)
Provision of any type of CPR by lay bystander[b]	(n = 596)	(n = 954)	(n = 845)	(n = 1009)	(n = 1011)	(n = 4415)
No.	168	311	274	359	403	1515
% (95% CI)	28.2 (24.6-31.8)	32.6 (29.6-35.6)	32.4 (29.3-35.6)	35.6 (32.6-38.5)	39.9 (36.8-42.9)	34.3 (32.9-35.7)
Type of CPR by lay bystander[b]	(n = 168)	(n = 311)	(n = 274)	(n = 359)	(n = 403)	(n = 1515)
Conventional						
No.	135	166	144	124	97	666
% (95% CI)	80.4 (74.3-86.4)	53.4 (47.8-59.0)	52.6 (46.6-58.5)	34.5 (29.6-39.5)	24.1 (19.9-28.3)	44.0 (41.5-46.6)
COCPR						
No.	33	145	130	235	306	849
% (95% CI)	19.6 (13.6-25.7)	46.6 (41.0-52.2)	47.5 (41.5-53.4)	65.5 (60.5-70.4)	75.9 (71.7-80.1)	56.0 (53.5-58.5)
Positive neurologic status (CPC score = 1 or 2)[c]	(n = 591)	(n = 939)	(n = 832)	(n = 994)	(n = 961)	(n = 4317)
No.	14	52	39	42	35	182
% (95% CI)	2.4 (1.1-3.6)	5.5 (4.1-7.0)	4.7 (3.2-6.1)	4.2 (3.0-5.5)	3.6 (2.5-4.8)	4.2 (3.6-4.8)

Abbreviations: CI, confidence interval; COCPR, compression-only CPR; CPC, Cerebral Performance Category; CPR, cardiopulmonary resuscitation; VF/VT, ventricular fibrillation/ventricular tachycardia.
[a] Percentages may not add to 100.0% because of rounding.
[b] Fisher exact test: $P \leq .001$; test for trend: $P < .001$.
[c] Fisher exact test: $P = .03$; test for trend: $P = .92$.

Table 3. Survival and Odds Ratios for Various Risk Factors

	Survival		Odds Ratio (95% CI)	
Characteristic	No./Total No.	% (95% CI)	Crude	Adjusted[a]
Bystander CPR				
None	150/2900	5.2 (4.4-6.0)	1 [Reference]	
Conventional	52/666	7.8 (5.8-9.8)	1.55 (1.12-2.15)	0.99 (0.69-1.43)
COCPR	113/849	13.3 (11.0-15.6)	2.81 (2.17-3.64)	1.59 (1.18-2.13)
Witnessed arrest				
No	48/2423	2.0 (1.4-2.5)	1 [Reference]	
Yes	267/1992	13.4 (11.9-14.9)	7.66 (5.60-10.48)	4.26 (3.04-5.98)
Shockable rhythm				
Nonshockable	62/3020	2.1 (1.6-2.6)	1 [Reference]	
VF/VT	257/1511	17.0 (15.4-19.2)	9.75 (7.32-12.97)	5.16 (3.78-7.05)
EMS protocol				
BLS/ACLS	129/2689	4.8 (4.0-5.6)	1 [Reference]	
MICR	186/1726	10.8 (9.3-12.2)	2.40 (1.90-3.03)	2.21 (1.70-2.88)
Age categories, y				
≥80	29/858	3.4 (2.2-4.6)	1 [Reference]	
60-79	139/2032	6.8 (5.7-7.9)	2.10 (1.40-3.16)	1.78 (1.15-2.75)
18-59	147/1525	9.6 (8.2-11.1)	3.05 (2.03-4.58)	2.27 (1.46-3.53)
EMS response interval, continuous per minute			0.85 (0.80-0.90)	0.87 (0.82-0.93)
Survival by location				
Residential	195/3591	5.4 (4.7-6.2)	1 [Reference]	
Public location	120/824	14.6 (12.2-17.0)	2.97 (2.33-3.78)	1.48 (1.11-1.96)
Provision of therapeutic hypothermia				
No	286/4337	6.6 (5.9-7.3)	1 [Reference]	
Yes	29/78	37.2 (26.4-48.0)	8.38 (5.22-13.47)	3.59 (2.09-6.19)
Survival by sex				
Male	219/2951	7.4 (6.5-8.4)	1 [Reference]	
Female	96/1464	6.6 (5.3-7.8)	0.88 (0.68-1.12)	1.42 (1.07-1.88)

Abbreviations: BLS/ACLS, basic life support/advanced cardiac life support; CI, confidence interval; COCPR, compression-only CPR; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; MICR, minimally interrupted cardiac resuscitation (performed by EMS personnel); VF/VT, ventricular fibrillation/ventricular tachycardia.
[a] Adjusted for all other variables in final model (goodness of fit, $P = .98$, area under receiver operator characteristics curve = 0.854, N = 4415).

logistic regression model, except for witnessed arrest and heart rhythm), using the no CPR group as the reference group, were 1.09 (95% CI, 0.70-1.69) for the conventional CPR group and 1.90 (95% CI, 1.31-2.75) for the COCPR group. Survival increased significantly over time for the subgroup of witnessed arrests with a shockable rhythm (Table 2), from 10.8% in 2005 to 30.4% in 2009 (Fisher exact test, $P<.001$; test for trend, $P<.001$).

The intraclass correlation value of ρ for survival among EMS agencies was 4×10^{-5} (95% CI, 0-0.00614), indicating no significant clustering. GEE logistic regression (random effects model) analyses converged on the same model as ordinary logistic regression and ORs (and 95% CIs) were identical, confirming there was no clustering effect by EMS agencies.

We were able to determine neurologic status for 4310 of 4515 cases of out-of-hospital cardiac arrest (217/315 survivors) of whom 4.2% (95% CI, 3.6%-4.8%) had a good neurologic status (CPC score of 1 or 2) (Table 1 and Table 2). Proportion of individuals with good neurologic status differed significantly based on the type of CPR provided: no CPR, 86 of 2852, or 3.0% (95% CI, 2.4%-3.6%); conventional CPR, 34 of 651, or 5.2% (95% CI, 3.5%-6.9%); COCPR, 62 of 814, or 7.6% (95% CI, 5.8%-9.4%) ($P<.001$). The unadjusted ORs for a good neurologic outcome for bystander resuscitation comparisons were as follows: conventional vs none, 1.77 (95% CI, 1.18-2.66); COCPR vs none, 2.65 (95% CI, 1.89-3.71); COCPR vs conventional, 1.50 (95% CI, 0.97-2.30).

For arrests of presumed noncardiac etiology, COCPR was performed in 60.0% (95% CI, 54.6%-65.4%) of all patients who received bystander CPR. For arrests of respiratory etiology, COCPR was administered in 9 of 150 patients (6%; 95% CI, 2.2%-9.8%). Survival for noncardiac etiologies was similar regardless of the type of CPR: no CPR, 24 of 803 patients (3.0%; 95% CI, 1.8%-4.2%); conventional CPR, 6 of 130 patients (4.6%; 95% CI, 0.1%-8.3%); and COCPR, 7 of 195 patients (3.6%; 95% CI, 0.1%-6.2%) ($P=.51$).

Of 297 pediatric cases of out-of-hospital cardiac arrest (age <18 years), 150 patients (50.5%) received bystander CPR (148 cases for which the type of resuscitation was identified). The proportions of children who received COCPR, stratified by age, were as follows: younger than 1 year, 7 of 77 patients (9.1%; 95% CI, 2.5%-15.7%); age 1 to 12 years, 3 of 50 patients (6.0%; 95% CI, 0%-12.8%); and older than 12 years, 9 of 21 patients (42.9%; 95% CI, 19.8%-65.9%).

COMMENT

Bystander CPR is a critical but incompletely understood link in the chain of survival for individuals who experience out-of-hospital cardiac arrest.[3,4,17-19] Although bystander CPR is associated with increased survival,[2,4] the rate of performing this intervention remains unacceptably low.[4,20,21] This has been cited as a potentially correctable reason for the poor survival rates in most communities.[2,22] Suggested causes for the low CPR rates include fear of causing harm, fear of contracting infectious disease, the complexity of the psychomotor task, panic, and reluctance to make mouth-to-mouth contact.[21,23-26] Because of these and other factors, increasing bystander CPR rates has been difficult in most settings.[4,22,27]

For more than a decade, preclinical reports have raised the possibility that it is not necessary to perform active ventilation during CPR soon after sudden collapse from out-of-hospital cardiac arrest. Animal studies have shown COCPR to be at least as effective as conventional CPR.[7-10]

This study is the first of which we are aware to report an intentional effort to encourage and endorse COCPR to the public. We identified 3 major findings: a significant increase in the rate of bystander CPR (from 28.2% to 39.9%), an increase in the likelihood of bystanders performing COCPR vs conventional CPR (from 19.6% to 75.9%), and a significant independent association between COCPR and survival when compared with conventional CPR (adjusted OR, 1.60; 95% CI, 1.08-2.35).

To our knowledge, this is the first report of a relationship between a public education effort and an increase in the rate of bystander CPR in a statewide jurisdiction. The nature of this study precludes determining the relative contributions of the various components of this statewide initiative. Encouraging a technique that is easier to perform and more acceptable to the public may have helped increase the CPR rate independent of the public education efforts. Ultimately, we suspect that only the combination of a local, state, and national public education campaign and the endorsement of COCPR made this effort successful. The Hands-Only CPR campaign now being led by the American Heart Association across the nation is timely and has the potential to increase the likelihood of success in other settings.

Our findings are consistent with other clinical studies suggesting that COCPR is associated with at least equivalent outcomes compared with conventional bystander CPR.[6,11,12,21,26,28-30] Two relevant clinical investigations have been conducted in Japan,[21,26] but these differ from our approach in that COCPR was never taught to the Japanese public. Cultural issues led to a significant number of Japanese bystanders performing chest compressions without rescue breathing despite the absence of specific COCPR training. In a comparison of outcomes between the conventional and "cardiac-only" CPR cohorts, Iwami et al[26] found no statistically significant difference in survival between the cardiac-only and the conventional CPR groups. However, in the similar SOS-KANTO study with 4068 witnessed cardiac arrests, a higher proportion survived with good neurologic outcome after cardiac-only CPR compared with conventional CPR (adjusted OR, 2.2; 95% CI, 1.2-4.2).[21]

The 3 studies that randomized dispatcher-assisted CPR telephone instructions to teach either conventional or compression-only techniques showed a statistically nonsignificant increase in survival to hospital discharge for COCPR (10.4% vs 14.6%, $P=.18$[6]; 12.3% vs 15.5%, $P=.09$[28]; and 14.8% vs

19.1%, $P=.16$[29]). In the largest of these studies, there was a statistically significant increase in neurologically intact survival (18.9% vs 13.5%, $P=.03$).[28] In our study, there also was a significant difference between good neurologic status (CPC score of 1 or 2) in the COCPR group (62/814; 7.6%; 95% CI, 5.8%-9.4%) compared with the conventional CPR group (34/651; 5.2%; 95% CI, 3.5%-6.9%) ($P<.001$).

However, all 3 of the randomized trials[6,28,29] evaluated dispatcher-assisted CPR and, thus, studied cases of out-of-hospital cardiac arrest in which bystanders did not immediately attempt resuscitation. Cases were excluded from randomization if bystander CPR had been initiated prior to the 911 call. Thus, these studies compared delayed COCPR vs delayed conventional CPR and excluded bystanders trained in CPR—those who would have likely been the most proficient resuscitators.

Minimizing interruptions in chest compressions during resuscitation attempts by EMS personnel also has been associated with significant increases in survival when compared with conventional BLS/ACLS protocols.[11,30] Thus, it is not surprising that minimizing interruptions during bystander care would also be associated with improved outcomes.

There are multiple reasons COCPR might have advantages over conventional CPR techniques. These include the rapid deterioration of forward blood flow that occurs during even brief disruptions of chest compressions,[8,31] the long ramp-up time to return to adequate blood flow after resuming chest compressions,[8,31] the reduction of cardiac venous return with the use of positive pressure ventilation,[32] the complexity of conventional CPR,[21,33] the significant time required to perform the breaths,[28,33,34] the critical importance of cerebral and coronary circulation during arrest,[8,31,35,36] the reduced time required for emergency medical dispatchers to instruct a bystander over the telephone how to perform COCPR,[6] and the reluctance to perform mouth-to-mouth ventilation on strangers.[25,26,28,37]

Although our statewide program consistently and carefully advocated for conventional CPR for suspected noncardiac etiology arrests and children, we realize that lay rescuers might perform COCPR on these individuals. To assess this, we examined the incidence and survival of presumed noncardiac etiology arrests by the type of bystander CPR and found a similar and low survival rate regardless of the type of CPR. Also, the total number of pediatric cases of out-of-hospital cardiac arrest was relatively small (297/5272, 5.6%), and importantly, in the group in which rescue breathing would provide the most benefit (children aged <12 years), the proportion who received COCPR was only 10 of 127 children (7.9%).

The limitations of our observational study include that the COCPR intervention was not tested in a randomized controlled trial. However, because the decision to perform conventional CPR, COCPR, or no CPR was at the discretion of the bystanders, it would be impossible to randomize this intervention. We believe a large statewide prospective, observational design was the best methodology to evaluate this important issue. It is possible the outcome differences we found were associated with unknown confounders rather than the type of bystander CPR. We attempted to minimize this by prospectively collecting data known to affect outcomes. In addition, our a priori hypotheses supported by the results were biologically plausible based on multiple animal studies.[8,9,31]

There is also a risk of ascertainment bias in documenting the type of bystander CPR. EMS personnel who classified the type of bystander CPR may have misclassified COCPR vs conventional CPR. We attempted to prospectively mitigate the potential for ascertainment bias by intentionally and specifically training EMS personnel on how to document the presence and type of bystander CPR. The finding that lay bystanders performed COCPR 53.8% of the time overall compared with medical professional bystanders (7.8%) argues against a systematic bias in the documentation of CPR type. It is unlikely EMS personnel would misclassify type of CPR by lay bystanders differently than that by health care professionals.

CONCLUSION

Implementation of a 5-year, multifaceted, statewide public education campaign that officially endorsed and encouraged chest compression–only CPR was associated with a significant increase in the rate of bystander CPR for adults who experienced out-of-hospital cardiac arrest. Furthermore, chest compression–only CPR was independently associated with an increased rate of survival compared with no bystander CPR or conventional CPR.

Author Contributions: Dr Bobrow had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Bobrow, Spaite, Berg, Sanders, Kern, Vadeboncoeur, Clark, Mullins, Humble, Ewy.
Acquisition of data: Bobrow, Clark, Gallagher, Ewy.
Analysis and interpretation of data: Bobrow, Spaite, Berg, Stolz, Sanders, Kern, Vadeboncoeur, Stapczynski, LoVecchio, Ewy.
Drafting of the manuscript: Bobrow, Stolz, Sanders, Kern, Vadeboncoeur, Clark, Ewy.
Critical revision of the manuscript for important intellectual content: Bobrow, Spaite, Berg, Stolz, Sanders, Kern, Vadeboncoeur, Gallagher, Stapczynski, LoVecchio, Mullins, Humble, Ewy.
Statistical analysis: Bobrow, Stolz, Vadeboncoeur.
Administrative, technical, or material support: Sanders, Vadeboncoeur, Clark, Ewy.
Study supervision: Bobrow, Berg, Stapczynski, Ewy.
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