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Chest Compression Alone Cardiopulmonary Resuscitation Is Associated With Better Long-Term Survival Compared with Standard Cardiopulmonary Resuscitation

Florence Dumas, MD, PhD; Thomas D. Rea, MD, MPH; Carol Fahrenbruch MSPH; Marten Rosenqvist, MD, PhD; Jonas Faxén, MD; Leif Svensson, MD, PhD; Mickey S. Eisenberg, MD, PhD; Katarina Bohm, RN, PhD

Background—Little is known about the long-term survival effects of type-specific bystander cardiopulmonary resuscitation (CPR) in the community. We hypothesized that dispatcher instruction consisting of chest compression alone would be associated with better overall long-term prognosis in comparison with chest compression plus rescue breathing.

Methods and Results—The investigation was a retrospective cohort study that combined 2 randomized trials comparing the short-term survival effects of dispatcher CPR instruction consisting either of chest compression alone or chest compression plus rescue breathing. Long-term vital status was ascertained by using the respective National and State death records through July 31, 2011. We performed Kaplan-Meier method and Cox regression to evaluate survival according to the type of CPR instruction. Of the 2496 subjects included in the current investigation, 1243 (50%) were randomly assigned to chest compression alone and 1253 (50%) were randomly assigned to chest compression plus rescue breathing. Baseline characteristics were similar between the 2 CPR groups. During the 1153.2 person-years of follow-up, there were 2260 deaths and 236 long-term survivors. Randomization to chest compression alone in comparison with chest compression plus rescue breathing was associated with a lower risk of death after adjustment for potential confounders (adjusted hazard ratio, 0.91; 95% confidence interval, 0.83–0.99; P=0.02).

Conclusions—The findings provide strong support for long-term mortality benefit of dispatcher CPR instruction strategy consisting of chest compression alone rather than chest compression plus rescue breathing among adult patients with cardiac arrest requiring dispatcher assistance. (***Circulation*. 2013;127:435-441.**)

Key Words: cardiopulmonary resuscitation ■ chest compression ■ long-term outcomes ■ prognosis ■ resuscitation ■ survival

Out-of hospital cardiac arrest (OHCA) is a leading cause of death worldwide.[1,2] Resuscitation is challenging but achievable and relies in part on the chain of survival that includes early arrest recognition and emergency activation, early cardiopulmonary resuscitation (CPR), early defibrillation, expert advanced life support, and integrated postresuscitation care.[3] Specifically, early CPR performed by laypersons can double the chances of survival and provides an important foundation for subsequent links in the chain of survival.[4] In most communities, however, fewer than half of all persons who have had cardiac arrests receive bystander CPR before the arrival of professional rescuers.[4]

Clinical Perspective on p 441

Different approaches have been used to encourage and improve bystander CPR. One such approach is for the lay rescuer to provide bystander CPR that consists of chest compressions only in contrast to traditional CPR that comprises chest compressions interposed with rescue breathing. Chest compression alone is easier and quicker to initiate and so might provide for earlier CPR among a greater number of persons with OHCA.[5]

However, the comparative effectiveness of chest compression alone versus traditional CPR performed by laypersons

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From Emergency Medical Services Division of Public Health for Seattle and King County, Seattle, WA (F.D., T.D.R., C.F., M.S.E.); Inserm U970, Parisian Cardiovascular Research Center, Paris Descartes University, Paris, France (F.D.); Emergency Department, Cochin-Hotel-Dieu Hospital, APHP, Paris, France (F.D.); Department of Medicine, University of Washington, Seattle, WA (T.D.R., M.S.E.); Department of Internal Medicine, Nyköping Hospital, Nyköping, Sweden (J.F.); Section of Cardiology, Karolinska Institutet, Stockholm, Sweden (M.R., L.S.); and Karolinska Institutet, Department of Clinical Science and Education, Södersjukhuset, Stockholm, Sweden (K.B.).

Correspondence to Florence Dumas, MD, PhD, Inserm U970, Parisian Cardiovascular Research Center, Paris Descartes University, 56 rue Leblanc, 75015 Paris, France. E-mail florence.dumas@cch.aphp.fr

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is debatable.[6] Some experimental and observational studies suggest that chest compression only CPR may provide more benefit than traditional CPR, and yet other studies indicate that the type-specific benefits of CPR may depend on patient or circumstantial factors.[7–12] In randomized trials comparing dispatcher CPR instruction that consisted of chest compression alone or compression plus rescue breathing, results have not been conclusive.[5,13,14] A meta-analysis of these randomized trials restricted to those patients with a cardiac pathogenesis suggested a short-term survival benefit of chest compression alone.[15,16] However the ability to apply type-specific CPR according to arrest pathogenesis imposes an artificial selection that cannot be readily achieved in the field by laypersons or by dispatchers.[17]

We undertook long-term follow-up of subjects enrolled in 2 randomized trials comparing dispatcher CPR instruction to determine whether random allocation of type-specific CPR was associated with long-term survival.[13,14,18] The potential benefits of chest compression alone might be amplified following hospital discharge. This premise is derived from the appreciation that arrest survivors with underlying cardiac pathogenesis have a better long-term prognosis than those with noncardiac etiology.[19] In addition, some evidence suggests that brain recovery, in particular, may benefit from the chest compression alone strategy and that the effects of brain recovery might not be fully evident until more protracted follow-up.[20] Hence, we hypothesized that dispatcher instruction consisting of chest compression alone would be associated with better overall long-term prognosis in comparison with chest compression plus rescue breathing.

Methods

Study Design

This investigation was a retrospective cohort study that leveraged randomized trial design from the Dispatch Assisted Resuscitation Trial (DART) and the Swedish randomized trial entitled TANGO-telephone assisted CPR (TANGO).[13,14] These 2 studies compared whether survival to hospital discharge differed between persons with OHCA allocated to dispatcher CPR instruction consisting of chest compression alone versus chest compressions plus rescue breathing. The respective review boards approved the 2 trials including long-term surveillance to determine postdischarge survival. The studies are registered in http://clinicaltrials.gov (NCT00219687) and in Karolinska Clinical Trials Registry (http://www.kctr.se; CT20080012), respectively.

Subjects and Settings

Eligibility and enrollment have been described in detail previously. In brief, subjects were eligible for the DART study if they were unconscious and not breathing normally, bystander CPR was not ongoing, and the bystander was willing to receive instruction. Subjects were enrolled from June 1, 2004 to April 15, 2009. Dispatchers attempted to exclude those with cardiac arrest due to obvious trauma, drowning, or asphyxiation (from strangulation or suffocation), and patients who were <18 years of age, as well. The current investigation also excluded subjects from the DART study enrolled from the London site because long-term follow-up was not possible at this site.

In TANGO, subjects were eligible if the collapse was witnessed (seen or heard), and the subject was unconscious and not breathing normally. Subjects were enrolled from February 1, 2005 to January 31, 2009 for TANGO. The trial excluded patients with cardiac arrest caused by trauma, airway obstruction, drowning, or intoxication, and those who were <18 years of age.

In both study settings, emergency response is activated by calling an emergency number that connects to an emergency dispatcher. In DART communities, emergency medical services comprise of a 2-tiered system with the first tier consisting of basic life support provided by emergency medical technician–trained firefighters and advanced life support delivered by paramedics.[21] In TANGO communities, emergency medical services are provided by paramedics and nurses.[22] The emergency medical services in both study settings follows the core resuscitation strategy detailed by the International Guidelines.[23,24]

Study Intervention

Once determining that a case was eligible, dispatchers opened a sealed envelope (DART) or pulled a paper strip (TANGO) that contained type-specific CPR instruction. Chest compression alone instruction consisted of repeated cycles of compressions without instruction for rescue breathing. Chest compression plus rescue breathing instruction consisted of 2 initial rescue breaths followed by alternating 15 chest compressions.[13,14]

Covariates

Data were collected about the patient, circumstance, care, and outcome characteristics according to the Utstein data elements.[25] The study used information available from dispatch, emergency medical services, hospital, and death certificate records.

Outcome

In the current study, the outcome was vital status. In the DART study, vital status was determined by using State Vital Records and the Social Security National Death Index. In the TANGO study, vital status was determined by using the national cardiac arrest registry and national registry for personal information. Information about vital status was collected from respective national registries through July 31, 2011 and without knowledge of randomization status.

Statistical Analysis

We compared characteristics according to the intervention assignment (chest compression only or chest compression plus rescue breathing) with the use of the Pearson χ^2 test for categorical variables and nonparametric Wilcoxon test for continuous variables.

To compare long-term survival, we first used the Kaplan-Meier product-limit method to estimate survival at 1, 3, and 5 years according to randomization assignment. Comparison of survival curves used both the log-rank test and the Tarone-Ware test.[18] We also used Cox multivariable regression with the use of the Efron method to test the association between the intervention and survival adjusting for potential confounders including age, sex, initial rhythm, pathogenesis of the arrest, witnessed status, location of arrest, interval from call receipt to emergency medical services scene arrival, and study. The proportional hazards assumption was evaluated graphically and tested based on Schoenfeld residuals. Instead of excluding cases with missing covariates, we performed multiple imputation to incorporate all subjects in the fully adjusted model.[26] We conducted a sensitivity analysis, excluding those with missing covariates from the multivariable model.

We performed secondary analyses that included an efficacy comparison restricted to those who actually received bystander CPR. We evaluated the intervention association stratified by the period of follow-up defined as the early phase during the first 30 days following the arrest and the late phase occurring subsequent to day 30. We also performed subgroup analyses defined by arrest pathogenesis, presenting arrest rhythm, witnessed status, and emergency medical services response interval among witnessed arrests. We assessed for the differences in the intervention–outcome association among subgroups by including an interaction (cross-product) term between the intervention assignment and the covariate of interest. Finally, we also assessed the relationship between the intervention and survival among the primary Utstein group, bystander-witnessed arrest due to a cardiac pathogenesis presenting with a shockable rhythm.

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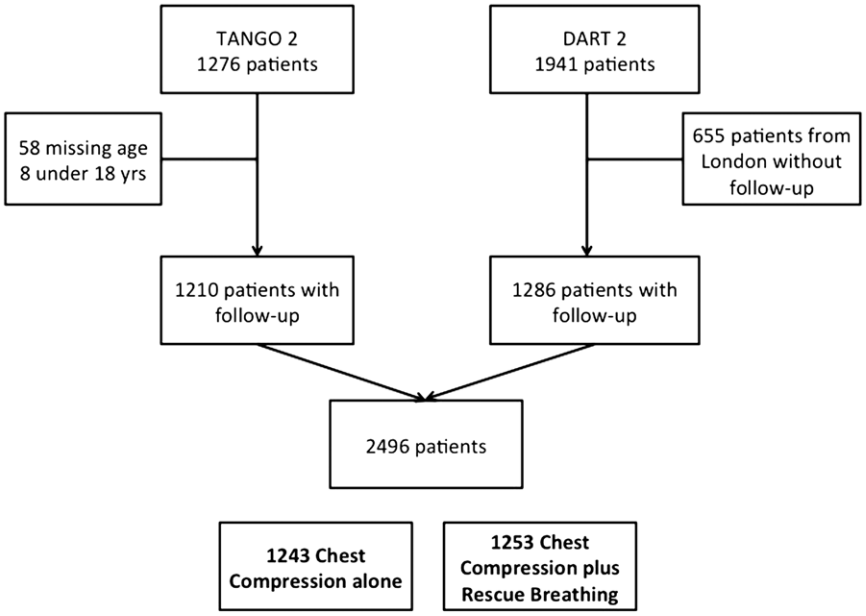

Figure 1. Flowchart. DART indicates Dispatch Assisted Resuscitation Trial; and TANGO, TANGO-telephone assisted CPR.

All tests were 2-sided. A probability value of ≤0.05 was considered as statistically significant. All analyses were performed by using STATA 11.2/SE software (StataCorp, College Station, TX).

Results

The original TANGO trial included 1276 subjects, whereas the original DART trial included 1941 subjects. Of those, 2496/3217 (78%) were included in the current study (Figure 1). The primary reason for exclusion was the London site (n=655) where long-term vital status could not be determined. Although overall cases from the London site were older, less often had witnessed collapse, and less frequently presented with a shockable rhythm, these characteristics were distributed equally between the intervention groups within the London site.

Of the 2496 subjects included in the current investigation, 1243 (50%) were randomly assigned to chest compression alone and 1253 (50%) were randomly assigned to chest compression plus rescue breathing. Baseline characteristics were similar between the 2 CPR groups (Table 1). Overall, men were twice as common as women. The median age was 66 years (25th, 75th percentiles [55,77]). About three quarters experienced an arrest due to a cardiac pathogenesis, whereas approximately one third presented with a shockable arrest rhythm.

During the 1153.2 person-years of follow-up, there were 2260 deaths. Overall survival was 11% (9.8–12.2) at 1 year, 10.6% (8.9–11.3) at 3 years, and 9.4% (8.3–10.6) at 5 years. The Kaplan-Meier curves comparing the 2 bystander CPR strategies demonstrated better survival for those randomly assigned to chest compression alone in comparison with chest compression plus rescue breathing (log-rank test P=0.03, Tarone-Ware P=0.009) (Figure 2). In the multivariable Cox regression model, the proportional hazards assumption was satisfied (χ^2 0.18, df=1, P=0.67). Randomization to chest compression only was associated with a lower risk of death after adjustment for potential confounders (adjusted hazard ratio [HR], 0.91; 95% confidence interval [CI], 0.83–0.99; P=0.02) (Table 2). The beneficial mortality association was similar when those with missing covariate status were excluded from the model (HR, 0.91; 95% CI, 0.84–0.99; P=0.03). When stratified by the early and late phase of follow-up (≤day 30 and subsequent to day 30), chest compression alone in comparison with chest compression plus rescue breathing was associated

Table 1. Baseline Characteristics According to Treatment Arm

	CC N=1243	CC+RB N=1253	*P*
Age, y, n (%)*			
18–55	314 (25.3)	321 (25.6)	0.81
56–66	316 (25.4)	314 (25.1)	
67–77	331 (26.6)	317 (25.3)	
>77	282 (22.7)	301 (24)	
Male sex, n (%)	842 (67.7)	841 (67.1)	0.74
Shockable rhythm, n (%)	423 (36)	421 (35.6)	0.86
Cardiac pathogenesis, n (%)	622 (73.7)	619 (75.6)	0.38
Location, n (%)			
Public	105 (8.7)	89 (7.4)	0.24
Residential	1105 (91.3)	1120 (92.6)	
Witnessed, n (%)	893 (72.1)	928 (74.1)	0.26
Mean interval EMS response, min, n (%)†	7.9	8.1	
≤6	653 (51.3)	543(48.3)	0.14
>6	619 (48.7)	582(51.7)	
Sites, n (%)			
DART	654 (52.6)	632 (50.4)	0.23
TANGO	589 (47.4)	621 (49.6)	

CC indicates chest compression alone; CC+RB, chest compression plus rescue breathing; DART, Dispatch Assisted Resuscitation Trial; EMS, emergency medical services; and TANGO, TANGO-telephone assisted CPR.

*Age is described according to its interquartile.

†EMS response is described to its median.

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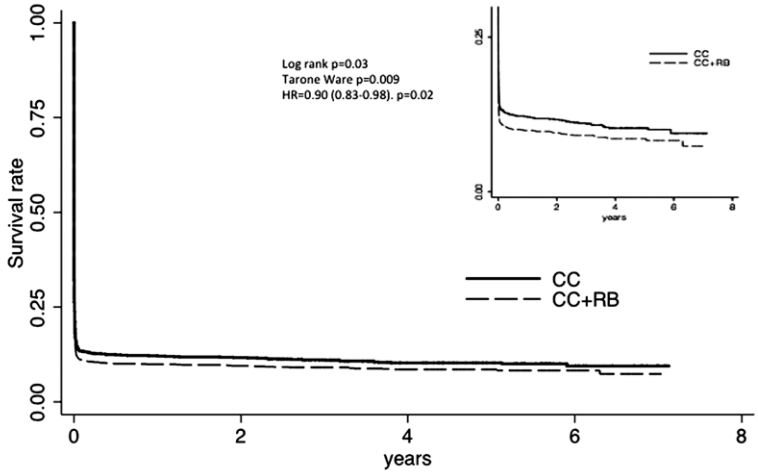

	1 year survival		2 years survival		5 years survival	
	Person-year	Survival Rates % (CI95)	Person-year	Survival Rates % (CI95)	Person-year	Survival Rates % (CI95)
Overall	291	11 (9.8-12.2)	560	10.6 (9.4-11.8)	799	9.4 (8.3-10.6)
CC	159	12.1 (10.3-14)	306	11.7 (10-13.5)	436	10.2 (8.6-12)
CC+RB	131	9.9 (8.3-11.6)	254	9.5 (8-11.2)	363	8.5 (7.1-10.2)

Figure 2. Association between intervention and survival according to subgroups of patients. CC indicates chest compression alone; CC+RB, chest compression plus rescue breathing; CI95, 95% confidence interval; and HR, hazard ratio.

with a lower risk of death during the early phase (adjusted HR, 0.90; 95% CI, 0.83–0.98; *P*=0.02). The intervention was not associated with mortality risk during the late phase (adjusted HR, 0.99; 95% CI, 0.62–1.58; *P*=0.99). During the study, 1918/2496 (77%) patients progressed through instructions and received the intended CPR. When restricting to this efficacy cohort, chest compression only was associated with a lower risk of death after adjustment for potential confounders (adjusted HR, 0.90; 95% CI, 0.82–0.99; *P*=0.03).

We did not observe strong evidence of subgroup differences, because none of the interaction terms between intervention status and the subgroup of interest attained statistical significance (Figure 3). We did however observe a lower risk of death among those with an arrest due to a cardiac pathogenesis (HR, 0.86; 95% CI, 0.77–0.97; *P*=0.01) and those with a witnessed arrest (HR, 0.89; 95% CI, 0.81–0.99; *P*=0.03). When restricted to the primary Utstein group—bystander-witnessed arrest due to a cardiac pathogenesis presenting with shockable rhythm (n=713)—randomization to chest compression alone in comparison with compression plus rescue breathing was associated with a lower risk of death (HR, 0.83; 95% CI, 0.71–0.99; *P*=0.03).

Table 2. Multivariable Predictors of Mortality

	Hazard Ratio	(95% CI)	P
Intervention	0.91	(0.83–0.99)	0.02
Age, y			
18–55 (referent)	1	–	–
55–66	1.17	(1.04–1.33)	0.01
67–77	1.27	(1.12–1.43)	<0.001
>77	1.39	(1.23–1.58)	<0.001
Male sex	1.05	(0.96–1.15)	0.29
VF/VT as initial rhythm	0.47	(0.42–0.52)	<0.001
Cardiac etiology	1.04	(0.91–1.19)	0.54
Location of cardiac arrest			
Residential	1	–	–
Public	0.80	(0.68–0.94)	0.006
Witnessed	0.75	(0.66–0.84)	<0.001
Time response >6 min	1.11	(1.02–1.23)	0.01
Site			
DART/TANGO	0.74	(0.66–0.82)	<0.001

95% CI indicates 95% confidence interval; DART, Dispatch Assisted Resuscitation Trial; TANGO, TANGO-telephone assisted CPR; VF, ventricular fibrillation; and VT, ventricular tachycardia.

Discussion

In this large, follow-up investigation of 2 randomized trials comparing dispatcher CPR instruction, patients with cardiac arrest randomly assigned to chest compression alone instruction had better long-term survival than patients randomly assigned to chest compression plus rescue breathing instruction.

Previous investigations have restricted or stratified findings according to arrest pathogenesis, because the survival effects of type-specific CPR may depend on pathogenesis.[7,8,11,27,28] Although these stratified findings provide useful mechanistic insights, dispatchers are challenged to quickly and correctly determine pathogenesis, making pathogenesis-based instruction impractical for real-world implementation.[17] Moreover, no study has evaluated the long-term outcomes of these patients. Although survival to hospital discharge is a clinically meaningful outcome, the short-term survival effects of type-specific CPR could be attenuated or amplified during convalescence and long-term follow-up. The current results provide important evidence that chest compression alone instruction can achieve better overall prognosis and should be considered the instructional approach for nearly all adult patients for whom dispatchers suspect cardiac arrest.

Based on the survival curve and short-term and long-term stratified analyses, we observed that the survival benefit of chest compression alone appears to be attributable to an early survival differential that persists over subsequent years of follow-up. The overall survival benefit was evident by the use of a number of different statistical comparison tests and

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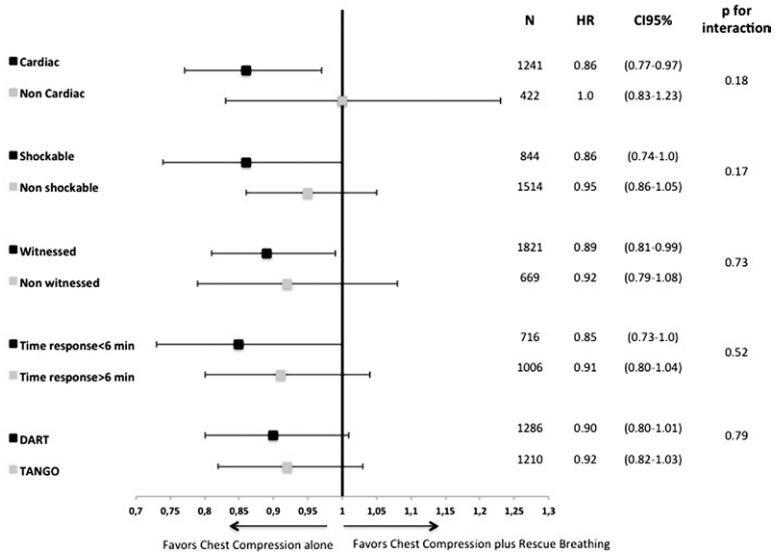

Figure 3. Overall survival according to the treatment arm. CI95 indicates 95% confidence interval; DART, Dispatch Assisted Resuscitation Trial; HR, hazard ratio; and TANGO,TANGO-telephone assisted CPR.

multivariable adjustments indicating that the observed difference in the overall study population is robust. We note specifically that the survival difference observed at early on was not amplified following discharge as hypothesized, but rather the survival curves were similar between the 2 groups during this follow-up. The main findings are important because the use of short-term surrogate outcome measures in resuscitation research often belie more meaningful long-term outcomes.[29–31] The results of the current study suggest that potential short-term outcome differences do translate to meaningful long-term public health benefits.[32]

Although not statistically definitive, the subgroup analyses were consistent with the understanding of the differential mechanism of chest compression alone versus chest compression plus rescue breathing such that the enhanced perfusion of chest compression alone would provide more benefit among those with cardiac pathogenesis arrest, shockable rhythm, or short collapse interval.[5,33–35] Importantly, we did not observe evidence of harm among those for whom oxygenation and ventilation might in theory be more important, such as noncardiac pathogenesis or unwitnessed arrest (Figure 3).

The study has limitations. The original studies were conducted independently and were not originally designed to ascertain long-term outcome. Common entry criteria and the randomization approach help protect against bias and enable combination of the study data. Each study used national and provincial death registries to ascertain mortality. Adjustment for study did not change the results, and the results were similar between the 2 studies. Although we observed survival differences, we were not able to ascertain functional status or quality of live during long-term follow-up, although favorable functional status has been associated with better long-term prognosis in the general population.[36] As part of the study design, dispatchers excluded pediatric patients or those with suspected cardiac arrest due to trauma, asphyxia, or drowning, so that the results do not apply to the modest number of arrests in these clinical and demographic groups. Rescue breathing was performed in a ratio of 2 breaths to 15 compressions given the study timeframe. One might expect that the differences would be attenuated if the ratio had been 2:30. Such a conclusion is uncertain given the incomplete understanding of the mechanisms responsible for the benefit of CPR and the fixed logistic considerations of providing rescue breathing.[37] Finally, although we leveraged larger sample size by combining the 2 studies, the investigation still had limited power to evaluate for subgroup or phase-specific intervention differences in the outcome.

The results are specific to dispatcher-assisted layperson CPR, although they provide a useful context to consider layperson CPR training and guidelines. Specifically, some evidence suggests that laypersons are especially challenged to perform effective rescue breathing even after training.[38] Thus, the results of the current study support the 2010 Guidelines that prioritize chest compressions regardless of training status or dispatcher assistance. Laypersons are directed to proceed to ventilations only if proficient in the technique of rescue breathing.

In conclusion, the findings provide strong support for long-term mortality benefit of dispatcher CPR instruction strategy consisting of chest compression alone rather than chest compression plus rescue breathing among adult patients cardiac arrest requiring dispatcher assistance. Emergency dispatchers have a vital role in resuscitation, and community stakeholders should leverage this important role to increase early arrest recognition and effective layperson CPR and, in turn, improve survival following cardiac arrest. Bystanders can proceed with the chest compression alone approach with the appreciation that this strategy on average provides optimal long-term survival benefit.

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Disclosures

None.

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CLINICAL PERSPECTIVE

Early bystander cardiopulmonary resuscitation (CPR) is the foundation for successful cardiac arrest resuscitation. Unfortunately, the majority of persons who have had cardiac arrests do not receive bystander CPR before arrival of professional rescuers. In comparison with traditional chest compression plus recue breathing, chest compression alone is a CPR strategy that simplifies the psychomotor requirement and may enable easier training and more widespread implementation. However, the long-term survival effects of chest compression alone versus compression plus rescue breathing among bystanders in a generalizable community setting is uncertain. The current study leveraged 2 randomized clinical trials of 2500 cardiac arrest events involving dispatcher-assisted CPR instruction to evaluate whether long-term prognosis differed among those who received chest compression alone in comparison with those who received compression plus recue breathing. Those who received chest compression alone experienced a 10% relative benefit in survival in comparison with compression plus rescue breathing. These findings provide strong support for long-term mortality benefit of a dispatcher CPR instruction strategy consisting of chest compression alone rather than compression plus rescue breathing among adult patients with cardiac arrest. Emergency dispatchers have a vital role in resuscitation, and community stakeholders should leverage this important role to increase early arrest recognition and effective layperson CPR and, in turn, improve survival following cardiac arrest. Bystanders can proceed with the chest compression alone approach with the appreciation that this strategy on average provides optimal long-term survival benefit.

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