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CLINICAL PAPER

Comparison of chest compression only and standard cardiopulmonary resuscitation for out-of-hospital cardiac arrest in Singapore

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Cardiac arrest;
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Summary
Objective: Chest compression only cardiopulmonary resuscitation (CC-CPR) without ventilation has been proposed as an alternative to standard cardiopulmonary resuscitation (CPR) for bystanders. However, there has been controversy regarding the relative effectiveness of both of these techniques.

We aim to compare the outcomes of cardiac arrest patients in the cardiac arrest and resuscitation epidemiology study who either received CC-CPR, standard CPR or no bystander CPR.
Methods: This prospective cohort study involved all out-of-hospital cardiac arrest (OHCA) patients attended to by emergency medical service (EMS) providers in a large urban centre. The data analyses were conducted secondarily on these collected data. The technique of bystander CPR was reported by paramedics who arrived at the scene.
Results: From 1 October 2001 to 14 October 2004, 2428 patients were enrolled into the study. Of these, 255 were EMS-witnessed arrests and were excluded. 1695 cases did not receive any bystander CPR, 287 had standard CPR and 154 CC-CPR. Patient characteristics were similar in both the standard and CC-CPR groups except for a higher incidence of residential arrests

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and previous heart disease sufferers in the CC-CPR group. Patients who received standard CPR (odds ratio (OR) 5.4, 95% confidence interval (CI) 2.1—14.0) or CC-CPR (OR 5.0, 95% CI 1.5—16.4) were more likely to survive to discharge than those who had no bystander CPR. There was no significant difference in survival to discharge between those who received CC-CPR and standard CPR (OR 0.9, 95% CI 0.3—3.1).

Conclusion: We found that patients were more likely to survive with any form of bystander CPR than without. This emphasises the importance of chest compressions for OHCA patients, whether with or without ventilation.

Introduction

In the chain of survival concept[1,2] provision of early bystander cardiopulmonary resuscitation (CPR) in out-of-hospital cardiac arrest (OHCA) patients is important to improve survival in sudden cardiac arrest. Survival rates for pre-hospital cardiac arrest vary in published reports from 2% to over 20%.[3]

Recently, chest compression only cardiopulmonary resuscitation (CC-CPR) without ventilation has been proposed as an alternative to standard CPR for bystanders.[4] Proponents of CC-CPR argue that it overcomes bystander reluctance to carry out mouth-to-mouth ventilation,[5–13] and is simpler to teach,[14–16] especially when giving instructions to an untrained bystander over the phone.[17–20] It may also result in fewer interruptions to chest compressions.[21–24] However there has been controversy regarding the relative effectiveness of CC-CPR.[25–27]

The current International Liaison Committee on Resuscitation (ILCOR) Advanced Cardiac Life Support Guidelines[28] recommend that CC-CPR should be encouraged only if rescuers are unwilling to do airway or breathing manoeuvres or are untrained in CPR and are uncertain how to do CPR. These guidelines also recognise the need for more research on the efficacy of CC-CPR.

In this study, we aimed to compare the outcomes of cardiac arrest patients in the cardiac arrest and resuscitation epidemiology (CARE) study who had received either CC-CPR, standard CPR or no bystander CPR.

Methods

The CARE study is a prospective, multi-phase, observational study of all eligible out-of-hospital cardiac arrest patients in Singapore. The study period was from 1 October 2001 to 14 October 2004.

Singapore is a city—state with a land area of 682.3 km^2 and a population of 4.1 million.[29,30] The population is multiracial with the major ethnic groups being Chinese, Malay and Indian. The island's emergency medical services (EMS) system is run by the Singapore civil defence force (SCDF) which currently operates 32 ambulances based in 15 fire stations and 14 satellite stations in a single tier system. Private ambulance operators do not convey emergency cases. Emergency ambulance patients are delivered to the six major public hospitals in the country that are equipped with modern emergency departments (EDs).

Singapore EMS is activated by a universal, centralised and enhanced '995' dispatching system run by the SCDF and which utilises computer aided dispatch, medical dispatch protocols, global positioning satellite (GPS) automatic vehicle locating systems and road traffic monitoring systems. However, during the study period, no dispatcher CPR instructions were being given.

Since 1996, ambulances in Singapore have been manned by specially trained paramedics (roughly equivalent to North American EMT-I). The paramedics undergo an 18-month training session which includes theory, hospital and ambulance attachments. They are able to provide basic life support (BLS) and defibrillation with automated external defibrillators (AED). They are able to give medications such as salbutamol, nitroglycerin, diazepam, aspirin, intravenous adrenaline, dextrose and saline infusions. They can also perform laryngeal mask airway insertion in cases of cardiac arrest.

The CARE study group includes representatives from the six major public hospitals in Singapore, the SCDF, Health Sciences Authority and the Clinical Trials and Epidemiology Research Unit, Ministry of Health, Singapore. The CARE phase I study described OHCA epidemiology in Singapore[31] and found survival from OHCA, in Singapore, to be 2.0%. Mean (S.D.) EMS response time was 10.2 (4.3) min. Mean (S.D.) time from call to defibrillation was 16.7 (7.2) min.

Patients of all ages were included. Exclusion criteria were those 'obviously dead' as defined by the presence of decomposition, rigor mortis or dependent lividity.

Patient characteristics (age, gender, race, past medical history), cardiac arrest circumstances (arrest location, whether witnessed, bystander CPR, whether chest compressions only, ventilation only or both were given, pre-hospital defibrillation, adrenaline (epinephrine) given), ECG rhythms, EMS response times and outcomes were prospectively recorded in a standard report compiled by EMS and EDs according to the Utstein style. Observations on the type of bystander CPR performed were based on prospective eyewitness reporting by the paramedics arriving at the scene. Paramedics would record whether they witnessed any ongoing bystander CPR, whether chest compressions only were given, ventilation only or both chest compressions and ventilation. However, there was no documentation on whether the rate of chest compressions by either observed method was in keeping with the recommended compression rates of 80 min^{-1} or 15:2 compressions: ventilations, as the case may be. These bystander CPR data were included with the mandatory data required from paramedics filling in their ambulance run reports, which needed to be submitted immediately on transferring care of the patient to the ED. ECG recordings were captured using the LIFEPAK 12 (Medtronic, Redmond, WA) and code summary printouts were subsequently verified by the study physician reviewers. EMS timings were automatically recorded by the computerised central dispatch system and ambulance AEDs. All watches and AEDs were synchronised with the central dispatch clock at the beginning of each shift. Institutional Review Board approval was obtained from all participating institutions.

The primary outcome measure for the study was survival to hospital discharge, which was defined as the patient leaving the hospital alive or survival to 30 days post-cardiac arrest, whichever came first. Outcomes were obtained by hospital chart review or patient assessment by physicians in the study team. Functional assessment of survivors was performed by reviewing physicians using standardised cerebral performance category (CPC) and overall performance category (OPC) scores according to Utstein guidelines.

Data management was carried out using the Clintrial application software, version 4.2. All data analyses were performed using SPSS version 15.0 (SPSS Inc., Chicago, IL), presenting descriptive statistics and frequencies. The comparison between mean scene times for the various groups was made using a *t*-test. The comparison between groups for the binary variables 'survival to discharge from hospital' and 'return of spontaneous circulation' was made using logistic regression and expressed in terms of the odds ratio (OR) and the corresponding 95% confidence interval (CI): an OR > 1 indicating an advantage.

Results

From 1 October 2001 to 14 October 2004, 2428 patients were enrolled into the study (Figure 1). Of these, 255 were EMS-witnessed arrests and were excluded. 1695 cases did not receive any bystander CPR while 478 received bystander CPR. Of these, 287 had standard CPR (ventilation and chest compression) and 154 had chest compression only.

Table 1 shows the characteristics of patients who received any bystander CPR compared to no bystander CPR. There was a slightly higher incidence of younger patients, more males, fewer residential arrests, more witnessed arrests, initial ventricular fibrillation and pre-hospital defibrillation in those who received bystander CPR. Univariate analysis showed there were significantly more survivors to discharge with bystander CPR (2.7% vs. 0.5%, $p < 0.01$) and more survivors to admission (10.0% vs. 7.0%, $p = 0.03$) although there was no significant difference in return of spontaneous circulation (ROSC) (17.4% vs. 14.4%, $p = 0.18$).

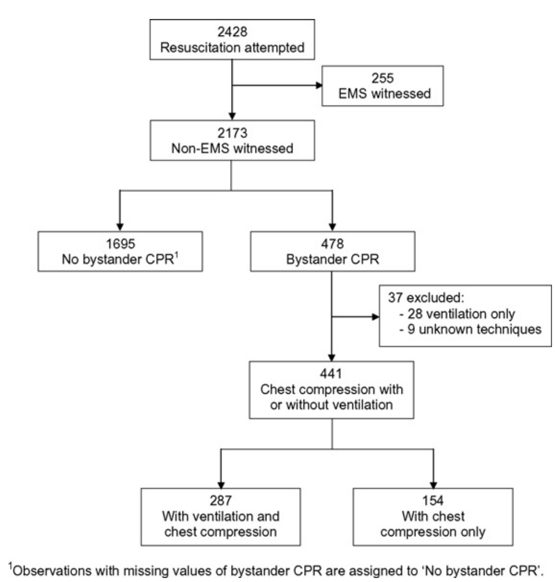

Figure 1 Study profile.

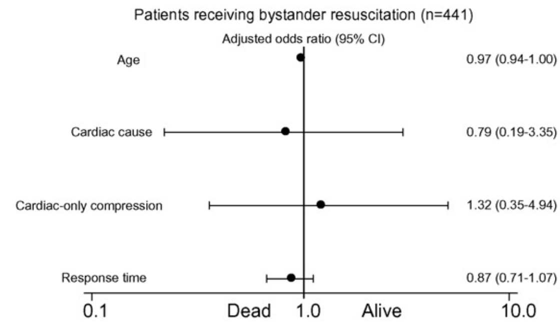

Figure 2 Factors associated with survival to discharge among patients receiving bystander CPR.

Table 2 shows the characteristics of the patients who received chest compression only compared to standard CPR. Characteristics such as age, race, whether witnessed by bystander, initial rhythm, EMS response times and pre-hospital defibrillation were similar in both groups. There was a higher incidence of residential arrests and previous heart disease in those who received CC-CPR compared to standard CPR. Univariate analysis showed there was no significant difference in survival to discharge (2.6% vs. 2.8%, $p = 1.00$), survival to admission (7.8% vs. 10.5%, $p = 0.79$) or ROSC (17.5% vs. 16.7%, $p = 0.98$).

Table 3 shows the subgroup analysis for study outcomes, comparing those who had no bystander CPR, standard CPR and chest compression only. The results are stratified by cause of arrest, presenting rhythm and response time. Patients who received standard CPR (OR 5.4, 95% CI 2.1—14.0) or CC-CPR (OR 5.0, 95% CI 1.5—16.4) were more likely to survive to discharge than those who had no bystander CPR. There was no significant difference in survival to discharge between those who received CC-CPR and standard CPR (OR 0.9, 95% CI 0.3—3.1).

Regarding factors associated with survival to discharge among patients receiving bystander CPR (Figure 2), increased age was marginally associated with a higher risk of death (adjusted OR 0.97, 95% CI 0.94—1.00) but CC-CPR did not have any significant association with survival (adjusted OR 1.32, 95% CI 0.35—4.94). Also, CC-CPR did not have any significant association with ROSC (adjusted OR 1.02, 95% CI 0.60—1.73).

Comparing the rates of ROSC and survival to discharge for CC-CPR and standard CPR stratified by initial rhythm, there appeared to be a higher rate of ROSC in the CC-CPR group in those with ventricular fibrillation or ventricular tachycardia, adjusted OR 2.4 (95% CI 1.0—5.4). However the difference in survival to discharge was not statistically significant, adjusted OR 1.5 (95% CI 0.3—7.0).

Table 4 shows the cerebral performance category and overall performance category of patients in the CC-CPR and standard CPR groups. Although there was a slightly higher proportion of patients with CPC 1 in the standard CPR group

Table 1 Baseline characteristics of the patients in the study

Characteristics	Any bystander resuscitation ($n = 478$)	No bystander resuscitation ($n = 1695$)	p-Value
Mean age ($n = 2160$; S.D.)	56.6 (19.7)	61.8 (19.0)	<0.001
Male (%)	356 (74.5)	1126 (66.4)	0.001
Race (%)			0.164
Chinese	326 (68.2)	1193 (70.4)	
Malay	70 (14.6)	245 (14.5)	
Indian	52 (10.9)	191 (11.3)	
Others	30 (6.3)	66 (3.9)	
Arrest location (%)			<0.001
Residence	194 (40.6)	1116 (65.8)	
Others	284 (59.4)	579 (34.2)	
Collapse witness (%)			<0.001
By bystander	370 (77.4)	948 (55.9)	
Not witnessed	108 (22.6)	747 (44.1)	
Initial rhythm ($n = 1978$, %)			<0.001
Ventricular fibrillation	154 (34.1)	232 (15.2)	
Ventricular tachycardia	1 (0.2)	2 (0.1)	
Asystole	193 (42.7)	906 (59.4)	
Pulseless electrical activity	104 (23.0)	386 (25.3)	
Defibrillated (%)	174 (36.4)	308 (18.2)	<0.001
Call receipt to vehicle stops, min (S.D.)	9.9 (4.5)	9.5 (4.3)	0.083
Call receipt to arrive patient's side, min (S.D.)	11.9 (4.8)	12.0 (5.9)	0.903
Vehicle arrive patient's side to leave location, min (S.D.)	9.3 (3.9)	10.4 (4.4)	<0.001
Vehicle leave location to arrive hospital, min (S.D.)	11.8 (6.1)	11.1 (6.4)	0.026
Past medical history ($n = 1899$, %)			
Heart disease	166 (39.7)	554 (37.4)	0.391
Diabetes	99 (23.7)	400 (27.0)	0.173
Hypertension	155 (37.1)	521 (35.2)	0.473
Stroke	34 (8.1)	107 (7.2)	0.531
Cancer	18 (4.3)	129 (8.7)	0.003
Others	100 (23.9)	292 (19.7)	0.061
Return of spontaneous circulation	83 (17.4)	244 (14.4)	0.175
Survival to admission	48 (10.0)	119 (7.0)	0.029
Survival to discharge	13 (2.7)	9 (0.5)	<0.001

(2.1% vs. 1.3%), the numbers were too small for meaningful statistical analysis.

Discussion

In this study, we found that patients who had received any form of bystander CPR had higher survival to discharge than those who did not have bystander CPR. However, there was no difference in survival to discharge between CC-CPR and standard CPR.

These results reinforce the importance of bystander CPR, which has also been demonstrated in previous studies.[32,33] Our study also appears to lend support to the relative importance of chest compressions compared to ventilations in the initial period after cardiac arrest. Previous observational studies have also noted that bystander CC-CPR does not seem to have poorer outcomes compared to standard CPR.[4,25,27,34] However we note that our number of survivors was too small to meaningfully analyse differences in post-arrest CPC/OPC, although at first glance, they do not appear very different.

There is some evidence from swine models of cardiac arrest to suggest that ventilation may not be essential in the initial 12 min of resuscitation.[23,35] However, when the animal model was simulated with an obstructed airway, as might often be the case in real life cardiac arrest, arterial blood was completely desaturated within 2 min.[36] Also, in a human model of cardiac arrest, passive ventilation during CC-CPR was limited in its ability to maintain adequate gas exchange.[26]

A more important factor is likely to be the problem of interruption of chest compressions with conventional CPR, resulting in less cycle time on chest compression and lower coronary perfusion pressures.[21–24] It is likely that patients receiving CC-CPR would have had more cycle time receiving

Table 2 Baseline characteristics of the patients receiving bystander CPR

Characteristics	Chest compression (n = 154)	Ventilation and compression (n = 287)	p-Value
Mean age (n = 439; S.D.)	58.6 (15.8)	56.0 (20.1)	0.138
Male (%)	115 (74.7)	218 (76.0)	0.765
Race (%)			0.413
Chinese	112 (72.7)	187 (65.2)	
Malay	18 (11.7)	47 (16.4)	
Indian	16 (10.4)	34 (11.8)	
Others	8 (5.2)	19 (6.6)	
Arrest location (%)			<0.001
Residence	76 (49.4)	91 (31.7)	
Others	78 (50.6)	196 (68.3)	
Collapse witness (%)			0.439
By bystander	118 (76.6)	229 (79.8)	
Not witnessed	36 (23.4)	58 (20.2)	
Initial rhythm (n = 419, %)			0.243
Ventricular fibrillation	50 (32.9)	101 (37.8)	
Ventricular tachycardia	1 (0.7)	0 (0.0)	
Asystole	70 (46.1)	104 (39.0)	
Pulseless electrical activity	31 (20.4)	62 (23.2)	
Defibrillated (%)	57 (37.0)	111 (38.7)	0.732
Call receipt to vehicle stops, min (S.D.)	9.4 (4.6)	10.2 (4.5)	0.103
Call receipt to arrive patient's side, min (S.D.)	11.5 (4.9)	12.2 (4.7)	0.190
Vehicle arrive patient's side to leave location, min (S.D.)	9.6 (4.1)	9.0 (3.9)	0.133
Vehicle leave location to arrive hospital, min (S.D.)	11.5 (6.0)	11.9 (5.7)	0.553
Past medical history (n = 381, %)			
Heart disease	63 (49.2)	91 (36.0)	0.013
Diabetes	32 (25.0)	59 (23.3)	0.716
Hypertension	49 (38.3)	97 (38.3)	0.991
Stroke	11 (8.6)	21 (8.3)	0.922
Cancer	6 (4.7)	9 (3.6)	0.592
Others	24 (18.8)	68 (26.9)	0.080
Return of spontaneous circulation	27 (17.5)	48 (16.7)	0.984
Survival to admission	12 (7.8)	30 (10.5)	0.786
Survival to discharge	4 (2.6)	8 (2.8)	1.000

chest compressions with the interruption for ventilation. In this study, bystander CPR would have been mostly in line with the ILCOR 2000 guidelines of 5:1 (two rescuers) or 15:2 (one rescuer) ratios of compressions: ventilations.[37] It remains to be seen whether these assumptions would still hold true with the advent of the new 2005 CPR guidelines,[28] which advocate a higher ratio of compressions to ventilations (30:2).

Limitations of this study include the fact that it was not a randomised controlled trial. However, characteristics of the CC-CPR and standard CPR groups were mostly similar and statistical adjustment was applied for any differences. Accuracy of reporting by paramedics of the type of bystander CPR being performed might also have been affected by the urgency of the situation at scene, which would likely be chaotic. However, we note that such data was collected based on immediate recall of the paramedics involved, not based on delayed recall.

Another limitation was that the quality of bystander CPR was largely unassessed, and it is difficult to make any definite conclusions based only on the observations of the arriving EMS crews. This limitation is significant, especially considering that the rates of continuous chest compressions performed may have been far below those recommended by Ewy and co-workers.[38] The findings of this study cannot be taken to presume agreement with the proponents of cardio-cerebral resuscitation who recommend such continuous compressions at the rate of 100 min^{-1} without ventilation. It could well be that less than optimal CPR is reported as 'chest compressions and ventilation', leading to an unfair comparison between chest compression only CPR (which may also have been very slow) and 'standard' CPR, resulting in no difference in either method. There is a need for good, prospective, randomised controlled trials comparing outcomes with continuous chest compressions at 100 min^{-1} vs. CPR at 30:2 (presuming these compressions

Table 3 Patients who survived to hospital discharge or 30 days post-arrest

	No bystander resuscitation (%)	Ventilation and chest compression (%)	Chest compression only (%)	Ventilation and chest compression vs. no bystander resuscitation	Chest compression only vs. no bystander resuscitation	Chest compression only vs. both ventilation and chest compression
				OR (95% CI)		
All patients	9/1695 (0.5)	8/287 (2.8)	4/154 (2.6)	5.4 (2.1–14.0)	5.0 (1.5–16.4)	0.9 (0.3–3.1)
Cause						
Cardiac	5/1122 (0.4)	5/202 (2.5)	3/120 (2.5)	5.7 (1.6–19.8)	5.7 (1.4–24.3)	1.0 (0.2–4.3)
Non-cardiac	4/573 (0.7)	3/85 (3.5)	1/34 (2.9)	5.2 (1.1–23.7)	4.3 (0.5–39.7)	0.8 (0.1–8.3)
Initial rhythm						
VF/VT	3/234 (1.3)	4/101 (4.0)	3/51 (5.9)	3.2 (0.7–14.5)	4.8 (0.9–24.6)	1.5 (0.3–7.0)
Asystole	1/906 (0.1)	0/104 (0.0)	1/70 (1.4)	NA	13.1 (0.8–212.0)	NA
PEA	1/386 (0.3)	1/62 (1.6)	0/31 (0.0)	NA	NA	NA
Response time						
≤8 min	4/665 (0.6)	4/96 (4.2)	2/69 (2.9)	7.2 (1.8–29.2)	4.9 (0.9–27.4)	0.7 (0.1–3.9)
>8 min	1/898 (0.1)	2/179 (1.1)	2/85 (2.4)	10.1 (0.9–112.4)	21.6 (1.9–240.9)	2.1 (0.3–15.4)

Data are numerator/total number or odds ratio (95% CI). CPR, cardiopulmonary resuscitation; PEA, pulseless electrical activity; VF, ventricular fibrillation; VT, ventricular tachycardia.

Table 4 CPC/OPC of survivors at 30 days in the chest compression only and ventilation with chest compression groups

Performance categories (%)	Chest compression only ($n = 154$)	Ventilation with chest compression ($n = 287$)
CPC 1	2 (1.3)	6 (2.1)
CPC 2	0 (0.0)	0 (0.0)
CPC 3	1 (0.6)	0 (0.0)
CPC 4	0 (0.0)	0 (0.0)
CPC 5	9 (5.8)	24 (8.4)
OPC 1	0 (0.0)	5 (1.7)
OPC 2	2 (1.3)	1 (0.3)
OPC 3	1 (0.6)	0 (0.0)
OPC 4	0 (0.0)	0 (0.0)
OPC 5	9 (5.8)	24 (8.4)

CPC, cerebral performance category; OPC, overall performance category.

are also at 100 min^{-1}). Only trials such as this will adequately address the issue of the value (positive or negative) of ventilations interposed in between compressions.

We note the relatively low survival rates in this study, which were consistent with previously reported survival in our city.[39] It is comparable to survival rates in other large cities[40] and may be related to factors such as problems with multistorey building access, delayed response times and bystander CPR rates. However, the low survival might also indicate a general low quality of bystander CPR, which unfortunately, is an untested hypothesis.

Finally, there may have been some variation in the post-resuscitation care received at the various hospitals, as this is difficult to quantify. Therapeutic hypothermia was not being used in any of the hospitals during the study period.

Conclusion

In this study of out-of-hospital cardiac arrest, we found that patients were more likely to survive with any form of bystander CPR than without. There was no difference in survival to discharge between CC-CPR and standard CPR. This provides additional evidence for the importance of chest compressions, whether with or without ventilation.

Conflict of interest

All the authors have neither commercial nor personal associations or any sources of support that might pose a conflict of interest in the subject matter or materials discussed in this manuscript.

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