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Clinical paper

Survival after dispatcher-assisted cardiopulmonary resuscitation in out-of-hospital cardiac arrest

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Abstract

Aim: Strategies to increase provision of bystander CPR include mass education of laypersons. Additionally, programs directed at emergency dispatchers to provide CPR instructions during emergency calls to untrained bystanders have emerged. The aim of this study was to evaluate the association between dispatcher-assisted CPR (DA- CPR) and 30-day survival compared with no CPR or spontaneously initiated CPR by lay bystanders prior to emergency medical services in out of hospital cardiac arrest (OHCA).

Methods: Nationwide observational cohort study including all consecutive lay bystander witnessed OHCAs reported to the Swedish Register for Cardiopulmonary Resuscitation in 2010–2017. Exposure was categorized as: no CPR (NO-CPR), DA-CPR and spontaneously initiated CPR (SP-CPR) prior to EMS arrival. Propensity-score matched cohorts were used for comparison between groups. Main Outcome was 30-day survival.

Results: A total of 15 471 patients were included and distributed as follows: NO-CPR 6440 (41.6%), DA-CPR 4793 (31.0%) and SP-CPR 4238 (27.4%). Survival rates to 30 days were 7.1%, 13.0% and 18.3%, respectively. In propensity-score matched analysis (DA-CPR as reference), NO-CPR was associated with lower survival (conditional OR 0.61, 95% CI 0.52–0.72) and SP-CPR was associated with higher survival (conditional OR 1.21 (95% CI 1.05–1.39).

Conclusions: DA-CPR was associated with a higher survival compared with NO-CPR. However, DA-CPR was associated with a lower survival compared with SP-CPR. These results reinforce the vital role of DA-CPR, although continuous efforts to disseminate CPR training must be considered a top priority if survival after out of hospital cardiac arrest is to continue to increase.

Keywords: Out-of-Hospital Cardiac Arrest, Dispatcher assisted CPR, Telephone CPR, Basic Life Support

Introduction

Cardiopulmonary resuscitation (CPR) prior to emergency medical services (EMS) arrival is associated with a higher rate of survival in cases of out-of-hospital cardiac arrest (OHCA).[1,2]

Strategies to increase provision of CPR include mass education of laypersons to become capable of recognizing cardiac arrest, placing an emergency call, and performing CPR. Such initiatives have been found to be associated with increased CPR rates.[1,3] However, this approach is costly and time-consuming. Furthermore, training has to be repeated regularly for skill retention.[4,5] Additionally, programs

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directed at emergency dispatch operators to provide CPR instructions during emergency calls to untrained bystanders have emerged.[6] Dispatcher Assisted CPR (DA-CPR) programs have been reported to increase CPR provision and to be associated with higher survival rates in communities where implemented.[7,8] European Resuscitation (ERC) Guidelines emphasize the role of the dispatch communicator to identify cardiac arrest and promptly initiate CPR instructions.[9] However, there are discrepancies in previous studies regarding the effect of CPR after dispatcher assistance compared to no CPR or bystander CPR not requiring dispatcher instructions.[10,11]

The aim of this nationwide register study was to assess the association between DA-CPR and survival in witnessed OHCA compared with no CPR (NO-CPR) or spontaneous CPR initiated by lay bystanders without dispatcher instructions (SP-CPR) prior to EMS arrival.

Methods

Design

An observational register-based cohort study. The study was approved by the regional board of ethics (dnr 2016/1532-31). The need for informed consent was waived. This research was done without involvement from patients or members of the public in the design, or conduct, or reporting, or dissemination plans of the research.

Swedish dispatch organization and dispatcher-assisted CPR

In Sweden, one emergency-coordinating agency (SOS-Alarm) handles all emergency calls to the national emergency number 112. In cases of medical emergencies, SOS-alarm coordinates the triage and dispatch of EMS in 18 of 21 administrative areas. In the remaining three areas the call is redirected to local medical-dispatch agencies. Medical dispatchers use a criteria-based dispatch protocol for identification of cardiac arrest. A cardiac arrest is to be suspected when the patient is described as unconscious with no or abnormal breathing. Dispatchers follow a standardized protocol for providing CPR instructions if callers have no CPR training. Since 2011 DA-CPR instructions have included chest compressions-only for adult victims of non-asphyctic OHCA, in accordance with ERC Guidelines 2010. For asphyctic cardiac arrest and for OHCA in children, instructions include chest compressions and rescue breaths in a ratio of 30:2.

Emergency medical services

Suspected OHCA triggers emergency dispatch of two ambulances. Swedish ambulances are generally staffed with two registered nurses with additional paramedic or anaesthesiology training. Units are equipped with Automated External Defibrillators (AEDs) and provide advanced cardiac life support (ACLS) in accordance with ERC guidelines.[9] In some regions first responders such as local fire fighters or police units can be dispatched to complement the EMS response. First responders are trained in Basic Life Support (BLS) and are equipped with AEDs. The use of first responders in Sweden has been described elsewhere.[12]

Swedish register for Cardiopulmonary Resuscitation (SRCR)

The Swedish Register for Cardiopulmonary Resuscitation (SRCR) is a register of EMS-treated OHCA in Sweden. All EMS organizations in all 21 areas report to the register. The register follows a standardized format of Utstein's definitions for reporting in OHCA.[13] Reports are completed by EMS crews after attending an OHCA and 30-day survival is obtained through linkage with the Swedish national population register. Reports are entered in the register only if bystanders or EMS attempted resuscitation. The SRCR is a national quality register and has been extensively described elsewhere.[1,14]

Patients and data collection

All consecutive cases of OHCA reported to the SRCR in 2011−2017 were collected. The time period was chosen to correspond to unchanged guidelines for DA-CPR provision. Cardiac arrest cases witnessed by EMS were excluded since they are not susceptible to bystander intervention. Patients with non-witnessed cardiac arrest were excluded from the primary analysis, the reason being that the time of cardiac arrest is usually unknown, and the impact of any treatment is reduced over time. Therefore, inclusion of cases of non-witnessed OHCA might attenuate differences between the different treatment groups. Patients receiving CPR by off-duty healthcare professionals prior to EMS arrival were also excluded in order to assess lay bystander performance. Finally, patients receiving rescue-breaths-only CPR, patients with missing data on either CPR prior to EMS arrival, dispatcher instructions or 30-day survival were excluded.

Exposure

Included patients were categorized into three exposure groups: patients not receiving any CPR prior to EMS arrival were classified as NO-CPR. Those who received CPR prior to EMS arrival were further categorized into those who received either CPR plus dispatcher assistance (DA-CPR) or CPR without dispatcher assistance, referred to as spontaneous CPR (SP-CPR).

Outcome

The primary outcome was 30-day survival. The secondary outcomes were the proportion of patients found with a shockable rhythm at first rhythm analysis and the proportion of patients with any return of spontaneous circulation (ROSC) at any time.

Statistical analysis

Descriptive statistics are presented as medians with interquartile ranges (IQRs) for continuous variables and counts and proportions for categorical variables.

Propensity score matching was used to adjust for differences in baseline characteristics. The following variables were used for matching: sex (male/female), age (years), aetiology (cardiac/non-cardiac), location (home/outside home), EMS response time (minutes), calendar year, and CPR by fire-fighters/police officers prior to EMS arrival (yes/no). To create three comparable cohorts, matching was done stepwise. First, DA-CPR and SP-CPR were matched, using nearest neighbour matching with a caliper width of 0.05. The matched DA-CPR cohort was then used for matching against the NO-CPR group, using the smallest possible caliper width (neighbour matching, caliper width = 0.21) whilst making sure that all cases in the DA-CPR group where kept after matching. Balances between baseline variables were assessed by using standardized mean differences. For the primary endpoint (30-day survival), the results are presented as conditional odds ratios (ORs) and absolute differences, with 95% confidence intervals. Sensitivity analyses were performed by using multinomial propensity scores (MNPSs) in a weighted logistic regression model.[15] First, the primary analysis was repeated, using MNPSs, and including the same variables as described above. To assess the association between exposure and outcome, adjusting for ventricular tachycardia/fibrillation (VT/VF), a secondary analysis was performed, including VT/VF in the model. Finally, non-witnessed OHCAs were analysed separately, using MNPSs and adjusting for the same variables as used in the propensity score matching. All tests were two-sided and p-values below 0.05 were considered statistically significant. All analyses were performed by using R, version 3.5.2 (R Foundation for Statistical Computing, 2019).

Results

Patient selection (Fig. 1, flow-chart)

During the study period a total of 36 309 EMS-treated cases of OHCA were registered in the SRCR. After exclusion of some classes of patients (non-witnessed cases, EMS-witnessed cases, patients who received CPR by off-duty healthcare professionals and patients with missing data on CPR prior to EMS arrival, dispatcher instructions or survival) a total of 15 471 patients were included in the primary analysis. Of these, 6440 (41.6%) received NO-CPR, 4793 (31.0%) received DA-CPR and 4238 (27.4%) received SP-CPR.

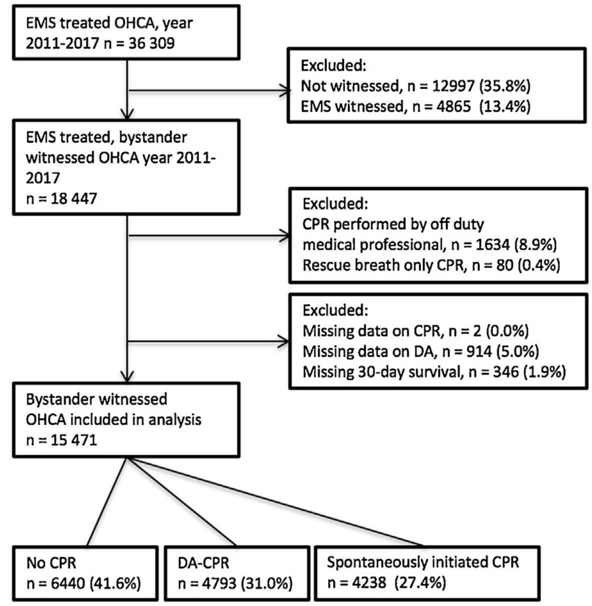

Fig. 1 – Flow chart of patient inclusion.
EMS = Emergency Medical Services, OHCA = Out-of-Hospital Cardiac Arrest, CPR = Cardiopulmonary Resuscitation, Off-duty healthcare professional = medical qualification (e.g. as for physician, nurse or nursing assistant), DA = Dispatcher Assistance

Baseline patient characteristics

Baseline characteristics of included patients are shown in Table 1. Patients receiving NO-CPR were more likely to be of female sex, were older, were more likely to have cardiac arrest at home, less likely to have cardiac arrest of cardiac aetiology and were less frequently reached by first responders before EMS. Patients in the SP-CPR group showed the highest percentages of males, of cardiac arrests occurring outside their residential locations, and first responders arriving before EMS.

Outcome before propensity score matching (Table 1)

The percentages of patients presenting with shockable first rhythms were 19.6% in the NO-CPR group, 33.5% in the DA-CPR group and 36% in the SP-CPR group ($p < 0.001$). The corresponding percentages for ROSC were 37.4%, 43.1% and 45.3% in the NO-CPR, DA-CPR and SP-CPR groups ($p < 0.001$). Survival to 30-days was 7.1% in the NO-CPR group, 13.0% in the DA-CPR group and 18.3% in the SP-CPR group ($p < 0.001$).

Propensity-score-matched cohorts

After propensity score matching a total of 3091 patients remained in each cohort, as shown in Table 2. (For balance before and after matching please see supplementary appendix Figure 1). The percentages of patients presenting with shockable first rhythm in the matched cohorts were 21.7% in the NO-CPR group, 34.9% in the DA-CPR group and 33.7% in the SP-CPR group. The corresponding percentages for ROSC were 38.2%, 43.6% and 43.0%, respectively.

Survival analysis in propensity-score-matched cohorts

Survival to 30-days in the propensity-score-matched cohorts is shown in Fig. 2. In the NO-CPR group 30-day survival was 9.0% (95% CI 8.0–10.0), in the DA-CPR group 13.6% (95% CI 12.4–14.8) and in the SP-CPR group 15.8% (95% CI 14.6–17.2). Using DA-CPR as reference, NO-CPR was associated with a lower survival rate (conditional OR 0.61, 95% CI 0.52–0.72), and SP-CPR was associated with a higher survival rate (conditional OR 1.21, 95% CI 1.04–1.39).

Sensitivity analysis

When the primary analysis was repeated using propensity score weights in a regression model (MNPSs) instead of propensity score matching, the results were similar (Please see sup. appendix Table 1).

When VT/VF was included in the model the direction of the association was the same for the NO-CPR group, but the adjusted OR was higher (0.76, 95% CI 0.66–0.87). In comparison of the DA-CPR and SP-CPR groups the results were similar (adjusted OR 1.19, 95% CI 1.05–1.35). (Sup. appendix Table 2).

When selection was restricted to only non-witnessed OHCA, survival to 30 days was 2.8% in the NO-CPR group, 3.0% in the DA-CPR group and 4.6% in the SP-CPR group. After adjusting for differences in baseline characteristics there were no statistically significant differences between NO-CPR (OR 0.91, 95% CI 0.69–1.21) or SP-CPR (OR 1.12, 95% CI 0.82–1.52) compared with DA-CPR. (Sup. appendix Tables 3 & 4.)

Table 1 – Baseline patient characteristics, before propensity score matching.

	NO	DA	SP-CPR	p	Missing
Number	6440	4793	4238		
Year, n (%)				<0.001	0.0
2011	907 (14.1)	531 (11.1)	636 (15.0)		
2012	906 (14.1)	564 (11.8)	593 (14.0)		
2013	969 (15.0)	546 (11.4)	688 (16.2)		
2014	951 (14.8)	580 (12.1)	558 (13.2)		
2015	950 (14.8)	727 (15.2)	617 (14.6)		
2016	861 (13.4)	884 (18.4)	602 (14.2)		
2017	896 (13.9)	961 (20.1)	544 (12.8)		
Sex (%)				0.002	0.0
Male	4351 (67.6)	3318 (69.2)	3017 (71.2)		
Female	2088 (32.4)	1475 (30.8)	1221 (28.8)		
Missing	1 (0.0)	0 (0.0)	0 (0.0)		
Age (median [IQR])	75 [66, 83]	70 [60, 79]	71 [61, 81]	<0.001	0.7
Call to EMS arrival (mins., median [IQR])	9 [6,14]	10 [7,16]	10 [6,15]	<0.001	3.7
Location (%)				<0.001	0.1
Residential	5055 (78.5)	3801 (79.3)	2350 (55.5)		
Public / Other	1372 (21.3)	990 (20.7)	1888 (44.5)		
Missing	13 (0.2)	2 (0.0)	0 (0.0)		
Cardiac aetiology, n (%)				<0.001	3.4
No	912 (14.2)	510 (10.6)	530 (12.5)		
Yes	5246 (81.5)	4186 (87.3)	3565 (84.1)		
Missing	282 (4.4)	97 (2.0)	143 (3.4)		
CPR TYPE (%)				<0.001	49.6
Compression only	0 (0.0)	2356 (49.2)	1459 (34.4)		
Standard	0 (0.0)	1908 (39.8)	2079 (49.1)		
NA / missing	6440 (100.0)	529 (11.0)	700 (16.5)		
First responder before EMS, n (%)	1222 (19.0)	1082 (22.6)	1028 (24.3)	<0.001	0.0
First rhythm VT/VF, n (%)				<0.001	2.1
No	5030 (78.1)	3132 (65.3)	2586 (61.0)		
Yes	1261 (19.6)	1607 (33.5)	1527 (36.0)		
Missing	149 (2.3)	54 (1.1)	125 (2.9)		
ROSC (any), n (%)	2409 (37.4)	2067 (43.1)	1920 (45.3)	<0.001	0.0
30-day survival, n (%)	**457 (7.1)**	**620 (13.0)**	**774 (18.3)**	**<0.001**	**0.0**

EMS = Emergency medical Services, CPR = Cardiopulmonary resuscitation, VT/VF = Ventricular tachycardia/ventricular fibrillation, ROSC = Return of spontaneous circulation.

Table 2 – Patient characteristics after propensity score matching*.

	NO-CPR	DA-CPR	SP-CPR
Number	3091	3091	3091
Year, n (%)			
2011	392 (12.7)	379 (12.3)	410 (13.3)
2012	412 (13.3)	396 (12.8)	402 (13.0)
2013	455 (14.7)	454 (14.7)	475 (15.4)
2014	402 (13.0)	388 (12.6)	404 (13.1)
2015	461 (14.9)	480 (15.5)	462 (14.9)
2016	487 (15.8)	495 (16.0)	476 (15.4)
2017	482 (15.6)	499 (16.1)	462 (14.9)
Sex, female, n (%)	957 (31.0)	948 (30.7)	955 (30.9)
Age (median [IQR])	72 [62, 81]	71 [62, 80]	71 [61, 81]
Call−EMS arrival, minutes (median [IQR])	10 [6,15]	10 [7,15]	10 [6,15]
Location, Residential (%)	2221 (71.9)	2161 (69.9)	2164 (70.0)
Cardiac etiology (%)	2696 (87.2)	2724 (88.1)	2727 (88.2)
First responder before EMS (%)	733 (23.7)	741 (24.0)	743 (24.0)
CPR type 30:2 (%)	0	1273 (46.5)	1451 (55.3)
First rhythm VT/VF, n (%)	660 (21.7)	1068 (34.9)	1019 (33.7)
Any ROSC, n (%)	1181 (38.2)	1348 (43.6)	1329 (43.0)
30-day survival n, (%)	**277 (9.0)**	**419 (13.6)**	**489 (15.8)**

* The following variables were used for matching; calendar year, sex (male/female), age (years), EMS response time (minutes), etiology (cardiac/non-cardiac), location (at home/outside home) and CPR by first responders such as fire-fighters/police officers (yes/no).

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	Survival 30 days (n)	% (95% CI)	Conditional OR (95% CI)
NO–CPR	277/3091	9.0 (8.0–10.0)	0.61 (0.52–0.72)
DA–CPR	419/3091	13.6 (12.4–14.8)	ref
SP–CPR	489/3091	15.8 (14.6–17.2)	1.21 (1.04–1.39)

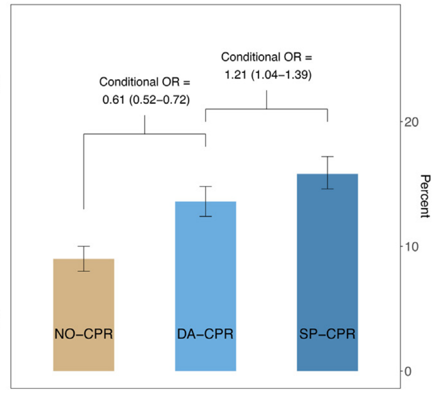

Fig. 2 – 30-day survival after propensity score matching.
CPR = Cardiopulmonary Resuscitation, DA = Dispatcher-Assisted, SP-CPR = Spontaneously initiated CPR without dispatcher assistance, OR = Odds Ratio.

Discussion

The main finding in this nationwide study of lay-bystander witnessed OHCA, is that DA-CPR was associated with a lower chance of survival compared with CPR spontaneously initiated by bystanders prior to EMS arrival. In addition, the results also reinforce the fact that DA-CPR is associated with a higher chance of survival compared with no CPR.

Is spontaneous CPR associated with higher survival compared with dispatcher-assisted CPR?

We found spontaneous CPR to be associated with a significantly higher survival compared with dispatcher-assisted CPR. This is in line with a recent large study from France.[11] However, our finding is slightly different from some previous reports showing no statistically significant difference between spontaneous CPR and DA-CPR. Rea et al. reported a higher rate of survival to discharge in connection with spontaneous CPR compared with DA-CPR, but after adjustments this difference was attenuated and was no longer of statistical significance.[8] Similar findings were reported by Wu et al. and Lee et al., with no evident difference in either survival or favourable neurological function at discharge.[16,17] There are methodological differences that could account for some of these differences. For instance, in the present study cases of non-witnessed OHCA were excluded from the primary analysis. In our exploratory analysis of non-witnessed cardiac arrests, we found a low survival rate in all groups and neither NO-CPR nor SP-CPR were statistically significantly associated with survival compared with DA-CPR. Therefore, inclusion of non-witnessed OHCA cases might dilute clinically meaningful differences among witnessed cardiac arrests. Also, even if dispatcher instructions are based on the same fundamental principles,[18] there might still be differences in local dispatch protocols, organization and performance among the study settings, which could influence the relative associations between different methods of CPR provision and survival.

Reasons for our findings could include a shorter time interval from cardiac arrest to CPR start among those capable of initiating spontaneous CPR. Time delays to start of CPR instructions are reported to wary between 140 to 328 seconds,[19] and may decrease the efficiency of dispatcher-assisted CPR.[20] We could not measure time delays from call to start of chest compressions in the present study since our data relies on EMS reports only and does not include evaluation of emergency call processes.

The quality of CPR may also differ among witnesses capable of initiating spontaneous CPR and those requiring DA-CPR. Nord et al. reported that CPR performed by off-duty healthcare professionals was independently associated with improved survival when compared with lay bystanders.[21] Therefore, in the present study patients receiving CPR carried out by off-duty healthcare professionals prior to EMS arrival were excluded in order to assess lay bystander CPR performance.

CPR prior to EMS arrival, and shockable rhythm at first rhythm analysis

One of the strongest predictors of survival in cases of OHCA is shockable rhythm at first rhythm analysis.[2] We found higher incidences of shockable rhythm among patients receiving both SP-CPR and DA-CPR, a difference that remained after matching. This finding might, at least in part, be an effect of chest compressions, preventing deterioration of ventricular fibrillation to asystole during EMS response time.[22] Therefore, we did not adjust for shockable rhythm in the primary analysis. However, when the analysis was repeated, adjusting for shockable rhythm, the difference between NO-CPR and DA-CPR was attenuated but still statistically significant. The association with survival when comparing DA-CPR and SP-CPR did not change (see supplementary appendix Table 2).

Impact of type of CPR – compression only, or compression plus ventilation

The current recommendation for dispatcher CPR instructions is compression only for adult OHCA victims. There are discrepancies concerning survival after compression-only CPR compared with standard CPR in observational trials.[23,24] In the present study CPR with compression only was slightly more common in the DA-CPR group than in the SP-CPR group, which might have influenced our finding.

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Dispatcher-assisted CPR is associated with a better survival rate compared with no CPR

Our finding of higher survival after dispatcher-assisted CPR vs. no CPR prior to EMS arrival is in line with previous reports from USA, Korea, Japan and France.[8,11,16,17,25]

Training large populations is time-consuming and expensive. It also seems that the effect of national initiatives to train the lay public in CPR takes decades to appear, i.e. to be reflected in higher CPR rates.[1,3] Implementation of structured DA-CPR programs has been shown to increase CPR rates (and is achieved more rapidly). One such initiative in Phoenix Arizona resulted in a 9% increase in CPR provision and a 3% increase in survival over a three-year period.[7] One obvious advantage is that dispatcher-assisted CPR can reach a broad population of OHCA victims, while training can be focused on relatively few people (dispatch operators). In the present study almost one third of all patients received DA-CPR. Notably, the baseline characteristics of the DA-CPR group before propensity score matching bore a close resemblance to the unfavourable characteristics of the NO-CPR group, in particular as regards a residential location at the time of the cardiac arrest (Table 1 and supplementary appendix Fig 1). This reinforces that DA-CPR is valuable when spontaneous CPR is not initiated, especially in circumstances with a low probability of bystander intervention, such as cardiac arrest occurring in residential locations.[1] Finally, the categories of CPR used in our study might not represent separate entities, since in real life there are probably different degrees of dispatcher involvement, also when spontaneous CPR is initiated. In Sweden, over five million people attended a basic CPR course between 1984−2018.[26] Bystanders with previous CPR training might be more willing to act when receiving CPR instructions and therefore our results might not be generalizable to populations with lower CPR awareness.

Future perspectives on dispatcher-assisted CPR

The AHA has issued performance goals for dispatcher-assisted CPR.[27] Uniform ways of reporting key metrics in dispatch call processes have been proposed.[28] Such information could be a valuable complement to the standardized Utstein reporting in OHCA and might identify specific elements in emergency call processing to be targeted in dispatcher training. Novel technology might provide new solutions to tackle some of the challenges of DA-CPR. Using artificial intelligence as a tool for correct identification and early recognition has shown promising results and is currently being evaluated prospectively.[29] In addition, video communications and app-based CPR support for callers could be future approaches to improve sensitivity and specificity of OHCA recognition, as well as to enable assessment of CPR quality, and may be aims of future research.[30]

Strengths and limitations

This study has several limitations. First of all, due to the observational nature of the study we cannot identify any causal relationship(s) or exclude unmeasured confounding. Second, reports are entered in the register by EMS with a risk of misclassification of exposure and how bystanders adhered to dispatcher instructions, since our data does not include audio review of dispatch calls. Third, we do not have any information on call processes and event times such as time to recognition of OHCA and initiation of CPR instructions, and therefore we could not adjust for such factors in our analysis. Fourth, we do not have data on in-hospital treatment such as early coronary angiography or targeted temperature management. Finally, we cannot report data on neurologic function of survivors due to a large amount of missing data, which is a major limitation. The strengths of the present study are the nationwide setting, the validity of the data and the large sample size.

Conclusions

In this nationwide study of witnessed OHCA, dispatcher-assisted CPR was associated with a higher chance of survival compared with no CPR. However, dispatcher-assisted CPR was associated with a lower chance of survival compared with CPR spontaneously initiated by lay bystanders. These results reinforce the vital role of DA-CPR, although continuous efforts to educate lay people and disseminate CPR training must be considered a top priority if survival after OHCA is to continue to increase.

Conflict of interest

This study was funded by the Swedish Heart and Lung Foundation. The funding body had no role in study design, collection of data, statistical analysis, or final writing of the article. All authors declare no conflicts of interests.

Contributorship Statement

This study was designed by Drs Riva, Hollenberg and Ringh. All analysis of the data was performed by Drs Riva and Jonsson. The first draft was written by Drs Riva, Hollenberg Claesson and Nord. All co-authors participated intellectually and practically in the writing of the article. Principal author Dr Riva had full access to all the data together with Drs Hollenberg and Jonsson.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2020.08.125.

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