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Bystander initiated actions in out-of-hospital cardiopulmonary resuscitation: results from the Amsterdam Resuscitation Study (ARREST)

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Abstract

The objective of this study was to analyze the functioning of the first two links of the chain of survival: 'access' and 'basic cardiopulmonary resuscitation (CPR)'. In a prospective study, all bystander witnessed circulatory arrests resuscitated by emergency medical service (EMS) personnel, were recorded consecutively. Univariate differences in survival were calculated for various witnesses, the performance of basic CPR, the quality of CPR, the performers of CPR and the delays. A logistic regression model for survival was developed from all potential predictors of these first two links.

From the 922 included patients, 93 survived to hospital discharge. In 21% of the cases, the witness did not immediately call 112, but first called others, resulting in a longer delay and a lower survival. Family members were frequent witnesses of the arrest (44%), but seldom started basic CPR (11%). Survival, when basic CPR performers were untrained and had no previous experience, was similar to that when no basic CPR was performed (6%). Not performing basic CPR, delay in basic CPR, the interval between basic CPR and EMS arrival, and being both untrained and inexperienced in basic CPR were independent predictors for survival. Basic CPR performed by persons trained a long time ago did not appear to have a negative influence on outcome, nor did basic CPR limited to chest compressions alone. The mere reporting that basic CPR has been performed does not describe adequately the actual value of basic CPR. The interval from collapse to initiation of basic CPR, and the training and experience of the performer must be taken into account. Policy makers for basic CPR training should focus on partners of the patients, who are most likely witness of an arrest.

Keywords: Cardiac arrest; Out-of-hospital cardiopulmonary resuscitation; Basic life support; Outcome

Resumo

O objectivo deste estudo foi analisar o funcionamento dos 2 primeiros elos da "cadeia de sobrevivência": "pedido de ajuda" e "suporte básico de vida" (SBV). Num estudo prospectivo registaram-se todas as paragens cardio-respiratória (PCR) consecutivas presenciadas por leigos e reanimadas pelo serviço de emergência médica (SEM). Foi feita análise univariada e calculadas as diferenças para os vários tipos de testemunhas, o desempenho de SBV, a qualidade do SBV, os reanimadores de SBV e os tempos decorridos. Desenhou-se um modelo de regressão logística para todos os potenciais preditores de sobrevida destes 2 elos.

Dos 922 doentes incluídos, 93 tiveram alta hospitalar. Em 21% dos casos a testemunha do colapso não chamou de imediato o 112, pediu outras ajudas e daí resultou atraso e pior sobrevida. Os familiares das vítimas foram frequentemente as testemunhas do colapso (44%) mas raramente iniciaram SBV (11%). A sobrevida quando o SBV foi feito por pessoas não treinadas e sem experiência prévia foi semelhante á das situações em que não foi realizado SBV (6%). Os preditores independentes de sobrevida identificados foram: não início de SBV; atraso no início do SBV; o intervalo de tempo entre o inicio de SBV e a chegada do SEM; falta de experiência e falta de treino em SBV. O SBV feito por pessoas treinadas muito tempo antes não pareceu influenciar a sobrevida, o mesmo sendo verdade para a realização de SBV só com compressões torácicas. O mero relato de que foi feito SBV

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não é suficiente para avaliar o valor do SBV. O intervalo entre o colapso e o início de SBV bem como a experiência de quem faz o SBV devem ser tidos em conta. O ênfase deve ser colocado no treino dos companheiros ou cônjuges dos doentes uma vez que são estes que mais frequentemente presenciam a PCR.

Palavras chave: Paragem cardio-respiratória; Reanimação extra-hospitalar; Suporte básico de vida; Resultado

1. Introduction

The chain of survival concept describes the actions necessary for an optimal chance to survive an out-of-hospital cardiac arrest [1]. The first two links in the chain of survival: access and basic cardiopulmonary resuscitation (CPR) are nearly always bystander initiated actions and the success of resuscitation efforts by health care professionals are highly dependent on the responsibly initial bystander. This study focussed on the period of circulatory arrest before the arrival of emergency medical service (EMS) personnel. We analyzed the actions and the quality of performance of the four groups most involved in the first two links: family, bystanders, general practitioners and police officers.

2. Patients and methods

2.1. Emergency medical service system

The EMS system is a one tiered system serving 1.3 million inhabitants in the Amsterdam area of 1030 km^2. The Netherlands has a national emergency telephone number 112, connected to regional dispatch centers. All ambulances were manned with a paramedic and a driver, who are trained to perform advanced CPR. Sometimes, the police were also activated after an emergency call for a suspected circulatory arrest. Telephone instructions for CPR were not used.

2.2. Study design

In a prospective study performed between June 1, 1995 and August 1, 1997 all consecutive out-of-hospital circulatory arrests confirmed by EMS personnel were recorded. Included were all bystander witnessed circulatory arrests, where EMS personnel attempted resuscitation. The ethics committees of all the study partners approved the study.

2.3. Data collection

We followed the Utstein recommendations for registration, definitions, and nomenclature [2]. Data collection was done by specially trained research personnel on the scene as has been described in detail previously [3]. Briefly, these personnel consisted of medical students, in a 24-h, 7 days a week coverage of the study area. When the ambulance dispatchers suspected a circulatory arrest and dispatched accordingly, the researcher "on call" was also directed to the scene. The researcher usually arrived during or immediately after the resuscitation attempt and debriefed the witness, bystanders, performers of basic CPR, and paramedics immediately after the resuscitation attempt to describe their actions and the times accurately. Estimation of the moment of collapse and the quality of basic CPR had a high priority. Rhythm strips from the ambulance were recovered and clock differences between the dispatcher's computer and the time stamp of the defibrillator were corrected immediately.

2.4. Time intervals and definitions

The interval between the collapse and the moment that the call reached the dispatch center was defined as 'time to call'. When a patient collapsed after the call but before arrival of the EMS personnel, this was recorded as 'call before collapse'. 'Time from call to EMS arrival' was the interval between the moment that the call reached the dispatch center up to the time that the EMS arrived at the patient's side. 'Time to basic CPR' was the interval between collapse and the start of basic CPR by lay persons. 'Time from basic CPR to EMS arrival' was the interval between the start of basic CPR to the EMS arrival at the patient's side. Persons who had received training in basic CPR procedures were labeled 'trained in basic CPR'. 'Experience in basic CPR' was recorded if a person had performed basic CPR on a human victim at least once before.

2.5. Statistical methods

Differences between proportions were tested with the χ^2 statistic, with a significant level of P-value < 0.05. Differences between medians were tested with the Median rank test. A logistic regression model was developed from all potential predictors for survival that could be known before the EMS arrived: the witness, 'time to call', the caller, 'time to basic CPR', 'time from basic CPR to EMS arrival', the identity training, history and experience of the performance of basic CPR, and the different ways of performing basic CPR. Stepwise elimination was used and based on the significance of each variable in the model and the significance in change of the log-likelihood, both tested with the χ^2 statistic and a P-value < 0.05. All statistics were performed in JMP 3.2 for the Apple Macintosh [4].

3. Results

3.1. The study cohort

In a study period of 26 months, 1685 patients had a circulatory arrest confirmed by EMS personnel. We excluded 400 patients who were not resuscitated by EMS personnel, 198 patients whose arrest was not witnessed and 165 patients whose onset of arrest was witnessed by EMS personnel. Of the remaining 922 patients, attempts to resuscitate were unsuccessful in 71% (658/922). After initial successful resuscitation 19% (171/922) of the patients died during hospital admission and eventually 10% (93/922) of the patients survived to hospital discharge.

3.2. The first link of the chain: access to help

3.2.1. The witness

The witnesses were nearly all bystanders (46%) or family members (44%) (Table 1). When a general practitioner was called for symptoms and witnessed the collapse, the chance of survival was statistically better than for any other witness. Police officers were seldom (1%) witnesses of an out-of-hospital circulatory arrest.

3.2.2. The call

In 95 cases, the call had reached the dispatch center before the patient collapsed (Table 1). There was a trend toward a better survival when the call was made before the arrest. In 827 cases, the call was made after the arrest and in 634 of these, the call was directly made to the dispatcher by dialing 112, resulting in a significantly better survival than when a call was first made to others. Who made the call had no significant influence on the outcome.

When the first call was directly made to the dispatcher, the median call delay was 0.8 min (Fig. 1(A)). When the first call was to others, such as relatives or the general practitioner, the median call delay was significantly longer, 2.8 min ($P < 0.001$). The median call delay of the call made by family members and bystanders was 0.9 and 1.0 min, not significantly different ($P = 0.11$), (Fig. 1(B)). The median call delay was significantly longer when the general practitioner or the police made the call, 2.0 and 1.8 min, with P-values of 0.02 and 0.02, respectively.

The dispatcher recognized the call as a circulatory arrest in 312 of the 827 cases, resulting in the dispatch of two ambulances simultaneously and, in 76 cases, also the police. In 69% (214/312) of these cases, basic CPR was started, significantly more than when the call was not recognized as an arrest, 46% (237/515), $P < 0.0001$. It was not documented whether basic CPR was initiated before or after the call to the dispatcher.

3.3. The second link of the chain: basic CPR

3.3.1. The basic CPR performer

In 45% of the cases, a bystander started basic CPR, in 25% a general practitioner, in 19% a police officer, and in 11% a family member or a relative (Table 2). The median time to the start of basic CPR for the general practitioner and the bystander was the same,

Table 1
The four groups most involved in first link of the chain of survival, their actions and the outcome

	Admitted alive		Discharged alive	
	Percentage (CI)	P-value	Percentage (CI)	P-value
Witness		0.240		0.002
Family members ($n = 408$)	25% (21–30)		6% (4–9)	
Bystander ($n = 427$)	31% (27–36)		12% (9–15)	
General practitioner ($n = 77$)	32% (22–43)		19% (11–28)	
Police ($n = 10$)	20% (0–45)		10% (0–29)	
Call in relation to collapse		0.667		0.112
Before collapse ($n = 95$)	30% (21–40)		15% (8–22)	
After collapse ($n = 827$)	28% (25–31)		10% (8–12)	
Call to		<0.001		<0.001
112 ($n = 634$)[a]	31% (28–35)		12% (9–14)	
Others ($n = 193$)[a]	19% (13–24)		3% (1–5)	
Call by		0.119		0.340
Family members ($n = 264$)[a]	25% (20–30)		7% (4–10)	
Bystander ($n = 479$)[a]	31% (27–35)		11% (8–14)	
General practitioner ($n = 65$)[a]	20% (10–30)		11% (3–18)	
Police ($n = 19$)[a]	32% (11–52)		11% (0–24)	

[a] Percentage among patients where the call was made after the collapse. CI is 95% confidence interval. CPR is cardiopulmonary resuscitation.

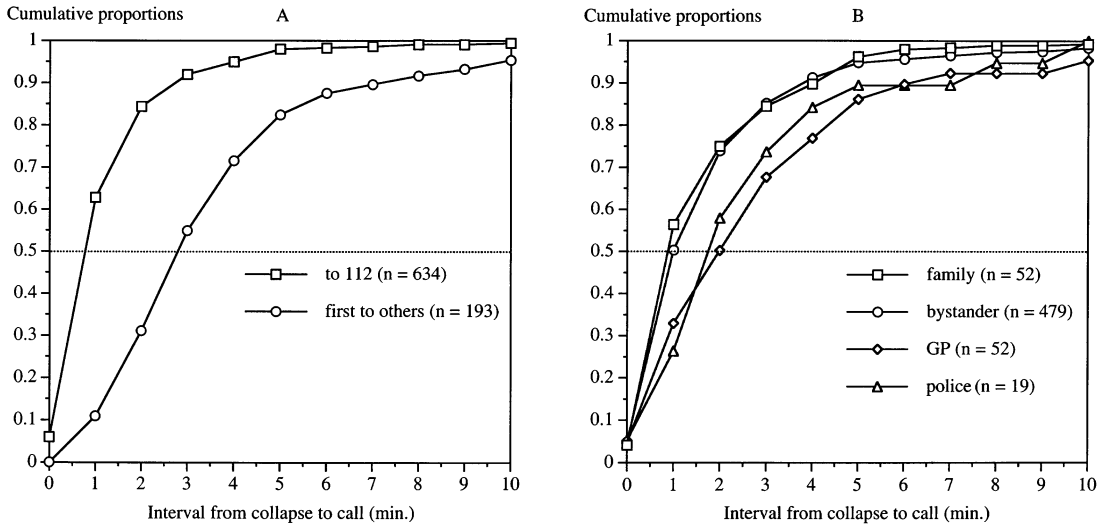

Fig. 1. Cumulative proportion of calls that reached the dispatch center in relation to the interval from the collapse to this call, for different situations. (A) The situation where the call was directly made to the dispatcher by dialing 112 and the situation the caller first called others. (B) The situations where the call was made by the four different groups involved in the first two links of the chain of survival. GP is general practitioner.

both 0.9 min ($P = 0.9$). Family members started significantly later, with a median delay of 1.4 min ($P = 0.007$), (Fig. 2(A)). The police had the longest median delay to the start of basic CPR of 5.0 min ($P < 0.0001$). Although there were large differences in survival among the basic CPR performers, the differences were not statistically significant.

3.3.2. The basic CPR performance

In the 493 patients who received basic CPR, the outcome was significantly better at all levels of training and experience, compared to those who did not have basic CPR (Table 2 and Fig. 3). Twenty-one family members had been trained in basic CPR procedures, representing 40% (21/52) of those who started basic

Table 2
The four factors most involved in second link of the chain of survival, their actions and quality of performance in relation to outcome

	Admitted alive		Discharged alive	
	Percentage (CI)	*P*-value	Percentage (CI)	*P*-value
Basic CPR performed		0.006		<0.001
Not performed ($n = 429$)	24% (20–28)		6% (4–8)	
Performed ($n = 493$)	32% (28–37)		14% (11–17)	
Basic CPR performer		0.037		0.303
Family members ($n = 52$)[a]	25% (13–37)		8% (0–15)	
Bystander ($n = 222$)[a]	39% (33–46)		17% (12–22)	
General practitioner ($n = 124$)[a]	27% (20–35)		13% (7–19)	
Police ($n = 95$)[a]	27% (18–36)		12% (5–18)	
Training and experience		0.631		0.004
Trained + experienced ($n = 268$)[a]	31% (25–37)		15% (10–19)	
Trained + inexperienced ($n = 123$)[a]	33% (25–42)		15% (8–21)	
Untrained + experienced ($n = 15$)[a]	47% (21–72)		40% (15–65)	
Untrained + inexperienced (n = 87)[a]	33% (23–43)		6% (1–11)	
Basic CPR techniques		0.570		0.713
MMV and CC ($n = 437$)[a]	33% (29–37)		14% (11–17)	
CC alone ($n = 41$)[a]	32% (17–46)		15% (4–25)	
MMV alone ($n = 15$)[a]	20% (0–40)		7% (0–19)	

[a] Percentage among patients where basic CPR was performed. CI is 95% confidence interval. CPR is cardiopulmonary resuscitation. MMV is mouth to mouth ventilation and CC is chest compression.

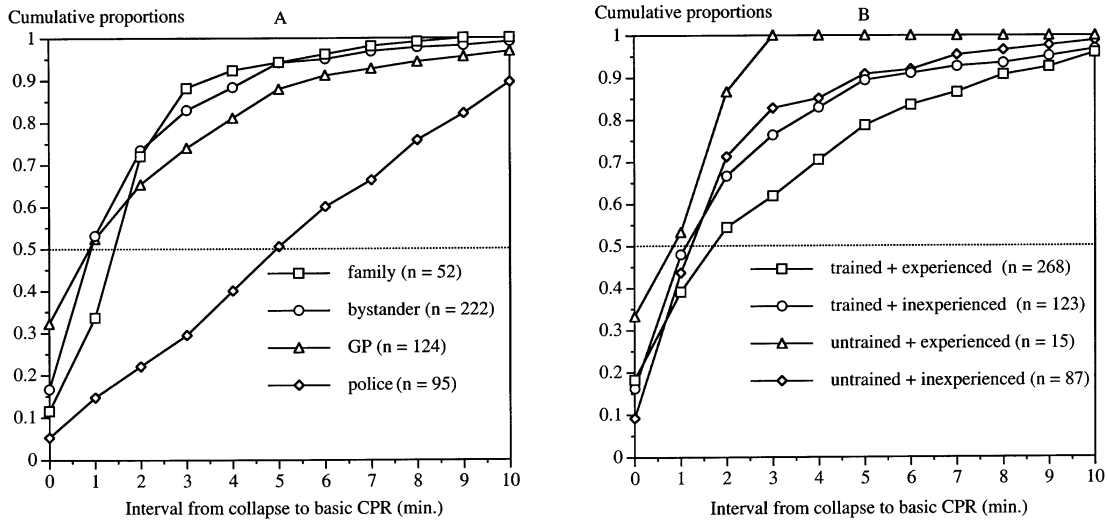

Fig. 2. Cumulative proportion of basic CPR performance in relation to the interval from the collapse to the start of basic CPR, for different situations. (A) The situation where basic CPR was performed by the four different groups most involved in first two links of the chain of survival. (B) The situation where basic CPR was performed by persons with a different history of training and experience. GP is general practitioner.

CPR. Of the 222 bystanders performing basic CPR, 151 (68%) had been trained in basic CPR procedures. Family members who performed basic CPR had experience in 13% (7/52) and bystanders in 37% (83/222). All general practitioners and police officers had been trained in basic CPR procedures. Of the general practitioners 91% (113/124) had experience in basic CPR performance, as did 84% (80/95) of the police officers.

The median delay to start basic CPR was significantly longer for those trained and experienced: 1.7 min compared to the other performers of basic CPR: 0.8, 1.1 and 1.2 min, respectively, $P < 0.0001$ (Fig. 2(B)). The median delay of the small group of untrained but experienced basic CPR performers was the shortest significantly $P < 0.0001$.

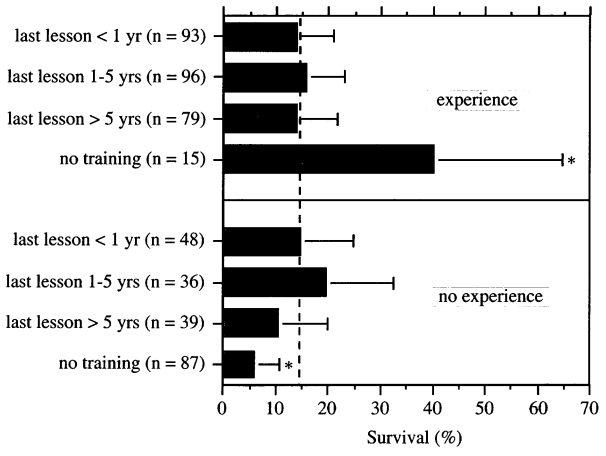

Fig. 3. Graphical presentation of the influence of the training history and experience of the basic CPR performer on survival. The dashed line is the survival of all cases where basic CPR was performed before the arrival of EMS personnel. Significant differences in survival are marked with an asterisk (*). Survival is discharged alive from the hospital.

Table 3
Predictors in a logistic regression model based on variables related to the first two links of the chain of survival

Predictors	Estimate	OR	95%-CI
Constant	0.40	1.50	0.68–3.31
Basic CPR not performed[a]	−3.18	0.04	0.02–0.10
Time from collapse to basic CPR[b]	−0.23	0.79	0.71–0.89
Time from basic CPR to arrival of EMS[b]	−0.19	0.83	0.76–0.90
Untrained + inexperienced basic CPR performer[a]	−1.02	0.36	0.14–0.94

[a] Binary predictor coded 0 or 1.
[b] Continuous predictor per minute delay. OR is odds ratio, CI is confidence interval. CPR is cardiopulmonary resuscitation, EMS is emergency medical service.

The interval since the last training lesson did not significantly influence outcome (Fig. 3). Basic CPR delivered by an untrained performer with experience resulted in the best survival. With neither training nor experience in basic CPR, survival was the worst and similar to that of patients who received no basic CPR at all.

In 89% of the cases, basic CPR performance consisted of mouth to mouth ventilation combined with chest compression (Table 2). Basic CPR consisted of chest compressions only in 8% and of mouth to mouth ventilation only in 3%. Initial resuscitation success was similar for the different forms of basic CPR and survival was not significantly different in the patients when basic CPR consisted of chest compression with or without ventilation.

3.4. Multivariate analysis of the potential predictors

When all factors mentioned were analyzed in a logistic model, a few variables proved independent predictors of survival (Table 3). When no basic CPR was performed before arrival of EMS personnel, survival was very low. A delay before basic CPR was initiated had a greater negative effect on survival than a delay between the start of basic CPR and the EMS arrival. When untrained persons without experience performed basic CPR, there was a lower probability of survival than then when a trained or experienced person performed basic CPR.

4. Discussion

This study focussed on the first two links in the chain of survival: 'access' and 'basic CPR'. In multivariate analysis, basic CPR performance before arrival of EMS personnel substantially improved survival. If the start of basic CPR was delayed, survival decreased significantly. Furthermore, what did matter was the training or experience of the basic CPR performer and not who started basic CPR.

Basic CPR skills as tested on a manikin decline in time [5]. We could not demonstrate that such a decline in skills resulted in a decrease in survival after real resuscitation efforts. However, univariate analysis showed that basic CPR performed by an untrained and inexperienced person, resulted in a survival similar to that when no basic CPR was performed. In the multivariate model, the negative effect on survival of not performing basic CPR was stronger than the effect of an untrained and inexperienced basic CPR performer. This difference in univariate and multivariate analysis could not be explained by the delay in the start of basic CPR, since this was identical. So, other predictors in their situation must have had an additional negative influence.

Family members were most likely to witness an arrest, but survival was worse then when others were witnesses, although they did not call later. Family members were less trained and experienced in basic CPR, seldom started basic CPR and when they did, the delay was long. Critically important was an immediate start of basic CPR efforts, the training or experience of the basic CPR performer, but not whether they were physicians, family members or other witnesses. Therefore, basic CPR training should not only seek the young and the active, but also the partners of potential patients as target groups, even when older. This was already emphasized many years ago and is again supported in our study [6].

Some researchers have already suggested that chest compression alone might be as effective as the combination of chest compression and mouth to mouth ventilation [7]. Our observations do support this suggestion: we found a similar survival in cases where chest compression was or was not accompanied by ventilation efforts. A markedly lower survival was observed when only mouth to mouth ventilation was delivered. This difference was not statistically significant, probably because of the small number of cases in this group.

When a circulatory arrest is not recognized or when panic prevails, a detour causes a delay. Obviously, the call itself does not contribute to the resuscitation efforts, but it is required for early activation of subsequent links in the chain. Therefore, it is understandable that the delay in the call itself was not a significant predictor in the multivariate model [8]. It is important that a call is recognized as that of a circulatory arrest, allowing the dispatcher to send EMS and first responders simultaneously and give pre-arrival instructions to the caller [9]. In the cases, where the dispatcher recognized an arrest, a high proportion received basic CPR probably because the witness and the caller immediately understood the true nature of the situation. So a paradox exists: instructions in performing basic CPR are especially needed for the caller who does not recognize the situation as a circulatory arrest.

Our multivariate analysis only contained potential predictors that could be known before EMS arrived at the patient's side. Also, unwitnessed arrests were excluded from this study, since no accurate time estimate was possible without a witness. Therefore, we did not include in the analysis: 'witnessing the arrest', 'initial rhythm' and the 'cause of the circulatory arrest' despite the fact that this was recommended earlier [10].

A limitation of this study is that measuring the quality of basic CPR performance was not feasible. We decided not to accept the judgement of quality of basic CPR by the EMS personnel: EMS personnel saw the basic CPR efforts at a late stage, they could be biased by the outcome, and EMS personnel immediately focussed their attention on their own task. Our research personnel usually arrived after the EMS personnel and did not observe the basic CPR performers. Therefore, we employed a substitute measurement and chose the previous training and experience in basic CPR procedures.

From our study, we conclude that the statement 'basic CPR performed' incompletely describes the actual value of basic CPR. The interval from collapse to initiation of basic CPR and the training and experience of the performer must also be taken into account. The importance of immediate initiation of basic CPR must be stressed in basic CPR courses. This study again records many patients for whom basic CPR was not performed at all. Even when it was performed, basic CPR by trained persons may be delayed because the most important witness (partner or other family) does

not know how to perform basic CPR or delays CPR. Policy makers for basic CPR training should focus more on the partners of those who are most likely to witness a circulatory arrest.

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