One-year neurological outcome after out-of-hospital cardiac arrest in Copenhagen - the effect of anoxia interval, early defibrillation - and ACD-CPR

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ABSTRACT:

OBJECTIVE: To assess survivors from out-of-hospital cardiac arrest (CA) after 3 and 12 months with Glasgow Liège Scale, National Institute of Health Stroke Scale (NIHSS), Barthel Index and Mini Mental State Examination (MMSE). Additionally, the effect of anoxia interval, early defibrillation and active compression-decompression cardiopulmonary resuscitation (ACD-CPR) on neurological outcome was assessed.

DESIGN: Non-randomized prospective cohort study, Utstein Style.

SETTING: Copenhagen, population 560085 (1995), area 99 km2.

PATIENTS: Consecutive out-of-hospital CA during 1 ½ years.

Main Outcome Measure: Primary end points were NIHSS and MMSE scores. Secondary end points were return of spontaneous circulation (ROSC), discharged alive and alive one year after CA. Materials: Two physician-manned advanced life support (ALS) units operating in rendéz-vouz mode with basic life support units.

RESULTS: Of 136 witnessed ventricular fibrillation (VF) of cardiac aetiology 24% (confidence interval (CI), 17-32) were discharged alive, and 19% (CI, 13-26) were alive one year after CA. After 3 and 12 months, neurological impairment was present in 16% (CI, 3-40) and 7% (CI, 0-34) of the neurologically examined patients, dependent of personal assistance to activities of daily living and mobilization. Neuropsychological sequelae were present in 21% (CI, 6-46) and 14% (CI, 18-43) at 3 and 12 months, respectively. ACD-CPR significantly (p=0.014) increased the chance of obtaining ROSC. ACD-CPR was significantly (0.032≤p≤0.038) associated with neurological outcome at 3 months after CA, but insignificantly (0.133≤p≤0.175) at 12 months.

CONCLUSION: The high proportion of survivors without neurological/neuropsychological sequelae adds the evidence that resuscitation from witnessed out-of-hospital VF by physician-manned ALS units is valuable.

KEYWORDS: Active compression-decompression; Advanced Life Support (ALS); Cardiac arrest; Neurologic dysfunction; Out-of-hospital CPR; Utstein template.

Introduction

Several studies of out-of-hospital cardiac arrests (CA) using Utstein recommendations (1) have reported rates of initial survival and survival to hospital dishcarge (2-20); a few also reported the one-year survival (2,12,13,14,16,19,20). In addition, some (2,6,7,11,12,14,15,19,20) reported the 5-point Cerebral Performance Category (CPC) score (1=good recovery to 5=brain death) (1).

Jaffe et al (21) have stated that "the present Utstein protocol does not provide meaningful outcome data regarding a variety of outcome measures, including the quality of surviving brain function, mental capacity, personality, or the recovery of independent living skills". Hsu et al (22) found that the CPC score at hospital discharge correlated poorly with the validated Functional Status Questionaire and a subjective quality-of-life assessment in survivors from out-of-hospital CA, and concluded that the validity of CA outcome assessments based on the unvalidated CPC as an outcome tool is questionable.

A former Utstein register-based cohort study of out-of-hospital CA in Copenhagen 1991-93 showed that discharge from hospital and one year survival was more likely if the collapse was witnessed ventricular fibrillation (VF) of cardiac aetiology, but neurological outcome was not assessed (23).

Consequently, we set the present Utstein study up to assess the survivors from out-of-hospital CA with Glasgow Liège Scale (GLS), National Institute of Health Stroke Scale (NIHSS), Barthel Index (BI) and Mini Mental State Examination (MMSE). In addition, we wanted to assess the effect of anoxia interval, early defibrillation with semi-automatic external

defibrillator (SAED) and active compression-decompression cardiopulmonary resuscitation (ACD-CPR) on the outcomes.

Our hypotheses were:

1. The shorter anoxia intervals, the better neurological/neuropsychological outcome.
2. Early defibrillation by the BLS team results in better neurological/neuropsychological outcome.
3. The use of ACD-CPR results in better neurological/neuropsychological outcome than STD-CPR.

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Abbreviations

ACD-CPR, active compression-decompression cardiopulmonary resuscitation; ALS, advanced life support; BI, Barthel Index; BLS, basic life support; CA, cardiac arrest; CPC, Cerebral Performance Category; ED, emergency department; EMD, electromechanical dissociation; EMS, emergency medical services; EMT, emergency medical technician; EMT-D, emergency medical technician trained in defibrillation; GLS, Glasgow Liège Scale; ICU, intensive care unit; MMSE, Mini Mental State Examination; NIHSS, National Institute of Health Stroke Scale; ROSC, return of spontaneous circulation; SAED, semi-automatic external defibrillator; STD-CPR, standard cardiopulmonary resuscitation; VF, ventricular fibrillation.

Materials and Methods

Design

In a non-randomized prospective cohort study we have used the Utstein Style template (1) to report all consecutive out-of-hospital CA considered for resuscitation in the City of Copenhagen occuring between January 15 1994 and July 15 1995. Survivors were examined with extended neurological, functional and neuropsychological examinations at 3 and 12 months after CA.

Population served

Copenhagen is the capital of Denmark. The municipality of Copenhagen (City) encompasses 99 km2 with a resident population of 560085 (1995), of which 18% were older than 65 years. The buildings are mainly blocks of flats, rarely more than five storeys high and usually without lifts (elevators).

The dispatch system

The dispatch center, staffed by specially trained firemen, covers emergency medical services (EMS) and is reached through the public three-digit emergency telephone number: 112. The nearest available emergency ambulance, a basic life support (BLS) unit, is dispatched as the first tier. In special cases such as CA, severe trauma, severe chest pain, etc, the advanced life support (ALS) unit is dispatched simultaneously as the second tier according to a protocol.

The EMS system of Copenhagen

The BLS units

The Copenhagen Fire Brigade comprised eight 24-h and 5 day/-evening BLS units distributed among the seven fire stations in the city of Copenhagen. Each vehicle was equipped with a CardioPump™ (Ambu International A/S, Denmark). Only 2 of the BLS units were equipped with a SAED: Heartstart® 3000 QR and Heartstart® 2000 QR (both from Laerdal Medical Corp., Norway).

The Frederiksberg Fire Brigade comprised two 24-h -BLS units in one fire station, each vehicle equipped with a SAED, Life Pack 200 (Physiocontrol, USA), but no CardioPump™.

The Gentofte Fire Brigade comprised two 24-h and 1 day/evening BLS units in one fire station, each vehicle equipped with a CardioPump™, and a SAED, DMS 940 (S&W Medico Teknik A/S, Denmark).

All BLS units were staffed by 2 professional emergency medical technicians (EMT) working as a stand-by basic at the fire stations. They were trained in manual external chest compressions and mask-ventilation with oxygen, but not endotracheal intubation or use of a laryngeal mask airway, and not authorized to give medication to patients suffering from CA. Resuscitation by EMT's had to be continued until relieved by the ALS team. The EMT's of the BLS units equipped with a CardioPump™ had been intensively trained in ACD-CPR (for minimum 2 months before this study began) and performed this at the scene. EMT's of the BLS units without a CardioPump™ performed standard-CPR (STD-CPR) with two-hand external chest compressions. The EMT's of the BLS units equipped with a SAED had been trained in defibrillation (EMT-D).

The ALS units

The Copenhagen Mobile Intensive Care Unit comprised two specially equipped station wagons as ALS units without a transport capacity for the patient, operating in a rendéz-vouz mode with the BLS units and staffed with a senior specialist in anaesthesiology/intensive care medicine and a specially trained EMT. The ALS team was based at the Copenhagen Municipal Hospital in central Copenhagen. During their daily service as part of this team the anaesthesiolgists were not involved in other duties at the hospital. The decision not to attempt resuscitation or to stop attempted resuscitation was the responsibility of the anaesthesiolgist, and based on clinical status and information from the family (terminal stage of cancer, dementia, Living Will, etc). Until September 5 1994 each ALS unit was equipped with a Corpuls 300 MSG-CP™ defibrillator (G. Stemple GmbH, Germany) and a separate Zoll-pacemaker; after this date they were equipped with a Cardio-Aid™ MC+ defibrillator (S&W Medico Teknik A/S, Denmark) with built-in Zoll pacing and SpO_2 measurement plus a removable memory card for extended data analysis (initial cardiac rhythm etc.).

ACD-CPR

Based on an anecdotal report of succesful resuscitation using a toilet plunger (24), Cohen et al (25) developed and investigated a handheld suction cup as an alternative to STD-CPR. The principle in the CardioPump™ is to deliver both compression and decompression in external chest massage on patients in CA. The active decompression results in a negative intrathoracic pressure between compressions, leading to improved venous return to the heart and increased stroke volume during subsequent compression, and thereby augmenting cardiac pump mechanism of blood flow (26-29). Increased rates of return of spontaneous circulation (ROSC) and 24-h survival were found in two in-hospital CA studies in the favour of ACD-CPR (30,31).

Data collection

Inclusion and exclusion

All patient data has been collected prospectively from the dispatch sheets and project forms completed by the anaesthesiologists, using the Utstein criteria (1), and followed up via hospital database systems by the investigators (MR and RT). Patients were transported to five hospitals in Copenhagen. Additionally, it has been necessary to collect data from some of the patients case records after obtaining consent. All patient identifiable data has been anonymized at the end of the study, which was approved by the Ethics Committee of Copenhagen.

All patients above 18 years in out-of-hospital CA treated with ALS were included, but CA due to non-cardiac causes (trauma, exsanguination, drowning, primary respiratory arrest, upper airway obstruction, cerebrovascular accident, drug overdose, suicide etc.) were excluded from calculations (1). Data were entered in a computerised database, SPSS/PC+™ V2.0 (SPSS Inc., Chicago, Ill, USA). Patients were subdivided in two groups based on the treatment of the BLS units: ACD-CPR or STD-CPR.

Time intervals

Time intervals were defined according to the Utstein recommendations (1): BLS/ALS call-response interval is the period from receipt of call by the EMS dispatch center to the moment the emergency response vehicle stops moving (the time from leaving the stopped vehicle until arriving at the patient's side and start treatment is not included). We also assessed the following intervals of presumptive anoxia, where the time from collapse to call is included: Collapse-to-bystander-CPR interval; collapse-to-BLS interval (STD-CPR or ACD-CPR performed by BLS team); collapse-to-defibrillation interval (by BLS team); collapse-to-ALS interval (treatment by ALS team) and collapse-to-ROSC interval.

Neurological examinations

Patients included in the study, who were still alive 3 or 12 months after their witnessed CA, were examined with GLS (32,33), NIHSS (34,35), BI (36,37) and MMSE (38,39) by one of the investigators (MR or RT). Like Roine et al (40) we have chosen 3 and 12 month follow-up since most of the improvement after stroke is believed to take place during the first year. The examinations took place, with the patients' or their family's consent, at the Dept. of Anaesthesiology at Hvidovre University Hospital of Copenhagen or at the patients' home. Each patient was examined at the same location and by the same investigator (MR or RT) both 3 and 12 months after CA, to eliminate interobserver variability. Patients suffering from a new CA were excluded from the neurological examination. Furthermore, all neurological examinations were supervised by a senior consultant in neurology to ensure that the patients were examined and scored correctly.

Outcome

The primary neurological end point of this study was the scores of NIHSS 3 and 12 months after CA, and the primary neuropsychological end point was the scores of MMSE 3 and 12 months after CA. Secondary end points were ROSC, discharged alive and alive one year after CA.

Statistical methods

Continuous data is reported as medians as time intervals usually are non-normally distributed. All data is reported with 95% confidence intervals (CI) where appropriate. Based on our previous study we estimated that 1100 patients with confirmed CA considered for resuscitation could be included within the data collection period of 1 1l2 year (23).

We used regression analysis (statistical software SPSS/PC+™ V2.0) with scores from GLS, NIHSS, BI and MMSE as the

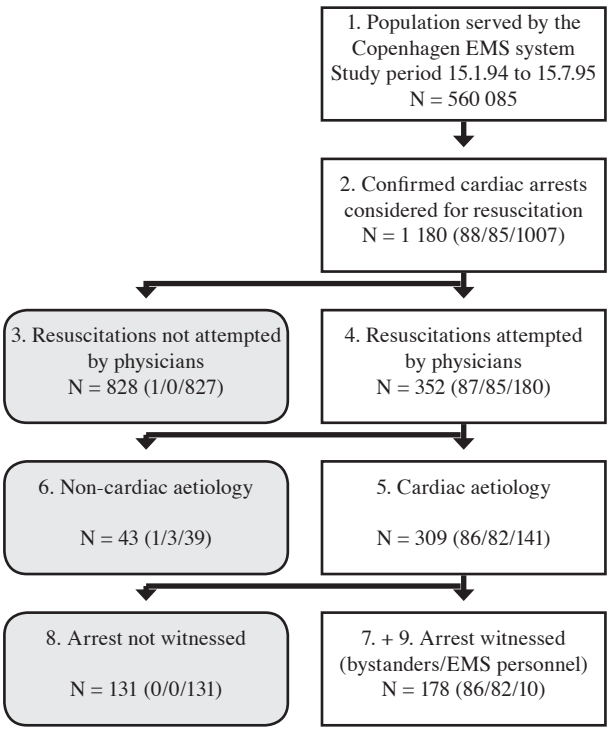

Fig. 1 Utstein Style Template for reporting all Out-of-Hospital Cardiac Arrest in Copenhagen 1994-95, (ACD-CPR/STD-CPR/No information) Continues in Figs. 2 & 3.

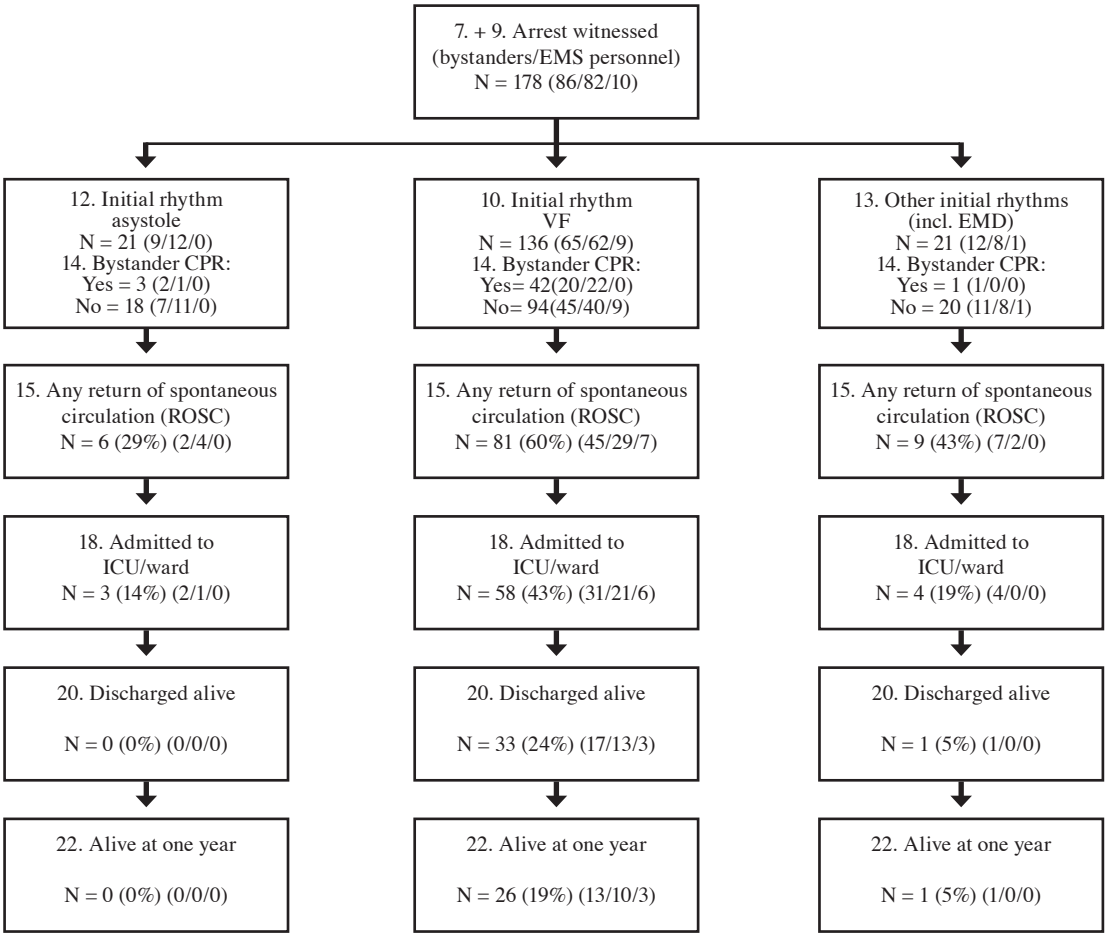

Fig. 2. Utstein Style Template for witnessed Out-of-Hospital Cardiac Arrest in Copenhagen 1994-95, data is broken down by initially recorded cardiac rhythm, (ACD-CPR/STD-CPR/No information). Boxes 1-6 are demonstrated in Fig.1.

dependent variables (dead patients were given the lowest scores); the independent variables were collapse-to-BLS interval and collapse-to-ALS interval; and covariates were age, gender, use of ACD-CPR, use of SAED and bystander CPR. The same calculations were made with ROSC (yes/no) as the dependent variable instead of neurological scores. $p < 0.05$ was considered statistically significant.

Results

The Utstein Style Template

Figs. 1-3 summarize the results according to the Utstein recommendations (1).

The median age was 69 (range 19-90) years, and 242 of 309 (78%; CI 74-83) patients were men.

Witnessed VF of cardiac aetiology

In the following we will only discuss patients with witnessed VF of cardiac aetiology according to the Utstein recommendations (1). Eighty one of 136 (60%; CI 51-68) patients obtained ROSC (Fig. 2). Of these 10 died before and 4 died during transport, and 9 died in ED. Fifty eight of 136 (43%; CI 34-51) were admitted to an ICU. Thirty three of 136 (24%; CI 17-32) were discharged alive, and 26 of 136 (19%; CI 13-26) were still alive one year after CA.

Time intervals

Median collapse-to-bystander-CPR interval was 1 (range 0-6) minute.

Median collapse-to-BLS (STD-CPR or ACD-CPR) interval was 4 (range -7-11) minutes. Median collapse-to-defibrillation (by BLS team) interval was 4.5 (range 0-11) minutes. Median BLS call-response interval was 3 (range 0-10) minutes.

Median collapse-to-ALS interval was 7 (range -7-20) minutes. Median ALS call-response interval was 6 (range 1-15) minutes.

Median collapse-to-ROSC interval was 12 (range -5-29) minutes.

Neurologically examined patients

Nineteen of 32 (59%; CI 41-76) patients alive 3 months after CA were assessed with neurological examinations, 5 died within one year, and the remaining 14 were examined 12 months after CA (Tab. 1). We also examined the only surviving patient after a witnessed EMD of cardiac aetiology, both 3 and 12 months after CA (Tab. 1, final line), but this case was not included in the statistical analyses since it was not VF. From Tab. 1 it is also seen that 10 of 19 (53%; CI 29-76) patients suffered from ischaemic heart disease before the CA.

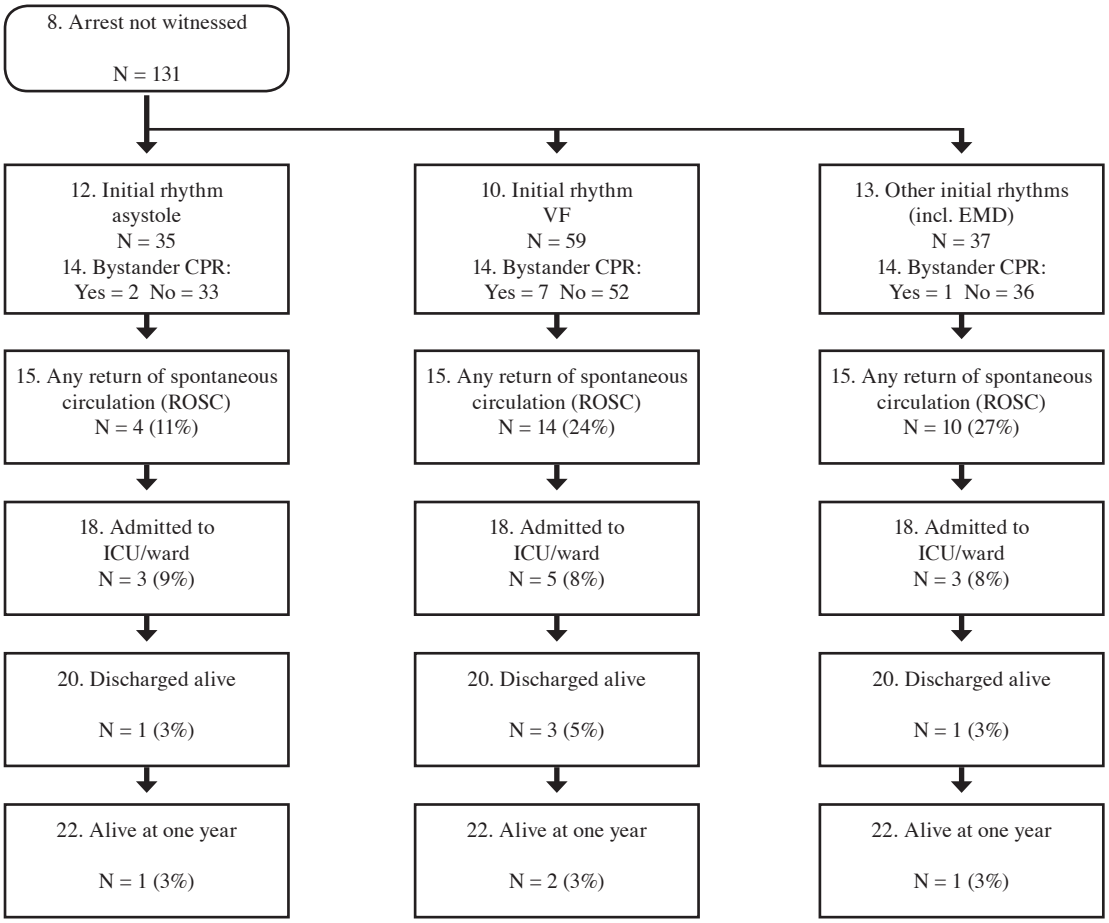

Fig. 3. Utstein Style Template for unwitnessed Out-of-Hospital Cardiac Arrest in Copenhagen 1994-95, data is broken down by initially recorded cardiac rhythm. Boxes 1-6 are demonstrated in Fig. 1.

Tab. 1. Neurologically examined patients – score data. GLS, Glasgow Liege Scale (min 3/max 20); NIHSS, National Institute of Health Stroke Scale (min 36/max 0); BI, Barthel Index (min 0/max 100); MMSE, Mini Mental State Examination (min 0/max 30); AH, arterial hypertension; AMI, acute myocardial infarction; AP, angina pectoris; CA, cardiac arrest; CABG, coronary artery by-pass graft operation; MVR, mitral valve replacement; PM, pacemaker; SVT, supraventricular tachycardia; WPW, Wolff-Parkinson-White syndrome. Patient no 66 had witnessed EMD as initial rhythm, all others had VF. -: deaths.

Patient no. (N=19)	**Outcome**								**Pre-existing diseases before cardiac arrest**
	G LS total score		**NIHSS total score**		**BI total score**		**MMSE total score**		
	3 mth.	**12 mth.**	**3 mth.**	**12 mth.**	**3 mth.**	**12 mth.**	**3 mth.**	**12 mth.**	
2	20	-	0	-	95	-	28	-	AMI 1981+86
3	11	-	33	-	0	-	0	-	WPW
4	20	-	0	-	95	-	24	-	None
11	20	-	9	-	85	-	20	-	Stroke 1990
19	20	20	1	3	95	100	27	26	AMI+PM 1991
37	20	20	1	0	100	100	27	28	AMI 1992
54	20	20	0	0	100	100	28	28	AP
62	20	20	1	1	100	100	29	27	MVR-+SVT
64	20	20	1	1	100	100	23	24	None
81	20	20	1	1	100	100	28	28	AMI 1983+SVT
96	20	20	0	0	100	100	30	28	None
110	20	20	7	4	75	70	26	27	Stroke1987+AMI/CA 1991+93
129	20	20	3	3	90	90	20	21	AMI 1992+AP
141	20	20	0	0	100	100	26	25	AH
148	20	20	2	0	100	100	26	26	Thyroid dysfunction
151	20	20	0	0	100	100	28	30	AMI 1993/Prinzmetals angina
165	20	20	0	0	100	100	28	28	AH
169	20	-	0	-	100	-	29	-	CABG+CA 1991
176	20	20	0	3	100	100	26	23	CA+CABG+PM 1988/CA 1991
66	20	20	1	0	100	100	29	29	None

Thirteen of the 32 (41%; CI 24-59) patients alive 3 months after CA were not assessed with neurological examinations: 8 refused, 3 had CA again, 1 was mentally retarded before CA (which made it impossible to estimate the exact neurological outcome of the CA), and with 1 patient it was impossible to make an appointment for neurological testing.

Prediction of ROSC and neurological outcome

In 9 of 136 (7%; CI 3-12) cases with witnessed VF of cardiac aetiology there were missing values on time, ACD-CPR or SAED, ending up with 127 patients with full data registration. Thirteen of these 127 patients were excluded from neurological examinations (see above). Of the remaining 114 patients: 60 (53%) were treated with ACD-CPR versus 54 (47%) with STD-CPR; 10 (9%) were treated with SAED versus 104 (91%) without; 35 (31%) received bystander CPR versus 79 (69%) without.

The regression analysis with ROSC as the dependent variable showed that ACD-CPR significantly (p=0.014) increased the chance of getting ROSC by an estimated 26% (CI 16-36). Neither SAED, bystander CPR, collapse-to-BLS interval nor collapse-to-ALS interval were significantly (all p≥0.65) associated with ROSC.

The regression analyses with GLS, NIHSS, BI and MMSE scores as dependent variables showed that ACD-CPR was significantly (0.032≤p≤0.038) associated with all neurological examinations 3 months after CA, but insignificantly (all p≥0.133) associated with all neurological examinations 12 months after CA (Tab. 2). The estimated effect of ACD-CPR on e.g. MMSE score at 3 months was +4.19 (p=0.036), an improvement of 14% ((4.19/(30-0)) of the full range from severe dementia to normal neuropsychological function. The effect varies slightly between GLS, NIHSS, BI and MMSE at 3 and 12 months, because they are closely correlated. Neither SAED, bystander CPR, collapse-to-BLS interval nor collapse-to-ALS interval were significantly (all p≥0.053) associated with all neurological examinations 3 and 12 months after CA.

GLS outcome

Only 1 of the 19 (5%; CI 0-26) neurologically examined patients (patient no. 3, a 27 year old woman with Wolf Parkinson White syndrome had severe brain damage caused by the CA) was in a vegetative stage after 3 months with a GLS=11, all other patients showed good recovery at both 3 and 12 months with maximum GLS=20 (Tab. 1).

NIHSS outcome

Three of the 19 (16%; CI 3-40) neurologically examined patients had a NIHSS≥4 after 3 months (Tab. 1): Patient no. 3 was in a vegetative stage with a NIHSS=33. Patient no. 11 (NIHSS=9: right-sided homonymous hemianopsia, motor weakness and ataxia of right arm and leg, mild sensory loss and mild aphasia) and patient no. 110 (NIHSS=7: motor weakness and ataxia of right arm and leg, mild aphasia and decreased distal motor function of right hand) had had a stroke years before the CA; but both patients had returned to their baseline appearance at the 3 month follow-up. At 12 month follow-up 1 of 14 (7%; CI 0-34) examined patients had a NIHSS≥4. Patient no. 110 showed a slight neurological improvement by 3 points, and patient no. 176 showed a slight neurological deterioration by 3 points compared with the 3 month examination; all other patients were still in good recovery.

BI outcome

At 3 month follow-up 3 of the 19 (16%; CI 3-40) neurologically examined patients had a BI≤85: Patient no. 3 with BI=0, dependent of personal assistance in all activities of daily living, waited for a room in a nursing home (but died in hospital 5 months after CA). Patient no. 11 had a BI=85 and needed little personal assistance in some activities of daily living. Patient no. 110 had a BI=75 and 70 at 3 and 12 months after CA, respectively, and needed some personal assistance in activities of daily living and mobilization. All other patients had BI>85 and lived independently in their homes (Tab. 1).

MMSE outcome

Three months after CA 4 of the 19 (21%; CI 6-46) neurologically examined patients had a MMSE<24 points suggestive of cognitive impairment (Tab. 1): Apart from patient no. 3 (vegetative state) and patient no. 11 (stroke sequelae, see above); patient no. 64 had problems in orientation, recall and language, and patient no. 129 had problems in orientation, attention/calculation, recall and language. At 12 month follow-up 2 of the 14 (14%; CI 18-43) examined patients had a MMSE<24 points.

Discussion

The objective of this study was to assess the neurological and

Tab. 2. The association between treatment and neurological score calculated with regression analysis. GLS, Glasgow Liege Scale range = 17 (20-3); NIHSS, National Institute of Health Stroke Scale range = -36 (0-36); BI, Barthel Index range = 100 (100-0); MMSE, Mini Mental State Examination range = 30 (30-0); ACD-CPR, active compression decompression cardiopulmonary resuscitation. [a] *p = 0,038,* [b] *p = 0,035,* [c] *p = 0,032,* [d] *p = 0,036*

Treatment	G LS		NIHSS		BI		MMSE	
	score, (% of range)		score, (% of range)		score, (% of range)		score, (% of range)	
	3 mth.	**12 mth.**	**3 mth.**	**12 mth.**	**3 mth.**	**12 mth.**	**3 mth.**	**12 mth.**
ACD-CPR	2,66[a]	1,54	-5,50[b]	-3,22	15,58[c]	9,75	4,19[d]	2,41
	(16)	(9)	(15)	(9)	(16)	(10)	(14)	(8)
Bystander CPR	2,59	2,16	-4,41	-4,51	12,69	11,75	3,52	3,68
	(15)	(13)	(12)	(13)	(13)	(12)	(12)	(12)

neuropsychological outcome of survivors with GLS, NIHSS, BI and MMSE 3 and 12 months after out-of-hospital CA. These examinations were found to be easy and quick to use by both investigators (MR and RT), and easy to understand and follow by the patients. Additionally, we wanted to assess the effect of anoxia interval, early defibrillation and ACD-CPR on neurological outcome.

GLS outcome

As to CA, Hassan et al (11) found that the immediate Glasgow Coma Scale on admission was a predictor of outcome and it was important to monitor its trend in the first 24 hours. In our study the immediate GLS was not available. After 3 and 12 months all the patients obtained the highest GLS=20, except for one (patient no. 3).

NIHSS outcome

We have chosen to examine survivors from out-of-hospital CA with NIHSS, as we suspect that CA causes a diffuse secondary cerebral ischaemia. Since most of the improvement after stroke is believed to take place during the first year, the follow-ups at 3 and 12 months appeared to be appropriate. In this study neurological impairment was seen in 16% of the examined patients after 3 months, and the greatest deviation from 3 to 12 months follow-up was 3 points. Like Wityk et al (35) we also conclude that most patients with early improvement remained so at 12-month follow-up.

BI outcome

Granger et al (37) found that an initial BI>40 in stroke patients defines a population with a greater proportion of discharges to home. We found that all patients were discharged to home, except for one (patient no. 3). Only 16% of the examined patients had a BI≤85 and needed personal assistance in activities of daily living and mobilization after 3 months. Initial BI scores within the first weeks after CA would have been suitable to predict the discharge location.

MMSE outcome

Roine et al (40) reported a rapid initial improvement of cognitive functions after out-of-hospital CA, but 60% of the survivors had moderate to severe neuropsychological deficits (most common was the impairment of delayed memory) 3 months after CA, which were still present in 48% 1 year after CA. They reported a mean MMSE score of 4, 13, 25 and 26, at 24 hours, 1 week, 3 and 12 months after CA, respectively (40). We found that only 21% and 14% of the examined patients had neuropsychological sequelae 3 and 12 months after CA, respectively. Patient no. 129 was suffering from beginning dementia before the CA, but had not been worsened.

Bystander CPR

We found no significant association between bystander CPR and ROSC/neurological outcome, which could be explained in the unequal distribution with 35 (31%) treated with bystander CPR versus 79 (69%) without.

Collapse-to-BLS interval and collapse-to-ALS interval

Neither collapse-to-BLS interval nor collapse-to-ALS interval were significantly associated with ROSC or neurological outcome, which could be due to the coarse estimation by giving the dead patients the lowest possible neurological score resulting in a skewed population.

Semi-Automatic External Defibrillation

In this study the use of SAED by the BLS teams was insignificantly associated with ROSC and neurological outcome. This was probably caused by the uneven distribution: 10 (9%) were treated with SAED versus 104 (91%) without, and the small number of patients treated.

ACD-CPR versus STD-CPR

Several out-of-hospital studies failed to demonstrate any significant benefit of ACD-CPR compared to STD-CPR (41-47). A meta-analysis (48) on ACD-CPR versus STD-CPR in out-of-hospital CA showed a significant improvement in 1h survival with ACD-CPR, which was largely due to the influence of the data from Paris (49). There were no statistically differences between the groups in hospital discharge and CPC score (48).

Like Lurie et al (50) and Plaisance et al (49), we also found a significant ($p=0.014$) increase in ROSC with ACD-CPR compared to STD-CPR. In our study ACD-CPR increased the chance of obtaining ROSC with an estimated extra 26% saved lives.

Plaisance et al (51) showed that ACD-CPR significantly improved the rates of hospital discharge and one-year survival, but not neurological outcome (CPC). We found an estimated significant ($0.032 \leq p \leq 0.038$) effect of ACD-CPR on the GLS, NIHSS, BI and MMSE scores 3 months after CA at 14-16% improvement of the range from none to normal function, but no significant effect was seen after 12 months.

Due to ethical considerations, we were not allowed to randomize this study concerning ACD-CPR, but we ended up with 60 (53%) patients treated with ACD-CPR versus 54 (47%) with STD-CPR. We conclude that ACD-CPR is temporarily lifesaving, but we do not have any guarantee that the covariates are covering the different situations in a CA. Perhaps it is not unimportant whether the CA occurs at home or at work? Or maybe the doctor of the ALS team felt obliged to continue the resuscitation in case there had been given bystander CPR, not to disappoint the bystander, despite the fact that the resuscitation was futile for the patient. ACD-CPR is more fatiguing and more difficult to perform than STD-CPR, and the many EMT's performance may have been inhomogeneous.

Conclusion

Our study showed that 24% patients were discharged alive, and 19% were still alive one year after a witnessed VF of cardiac aetiology. Only 16% and 7% of the neurologically examined

patients suffered from neurological impairment after 3 and 12 months, respectively, and were dependent of personal assistance to activities of daily living and mobilization. Neuropsychological sequelae were present in 21% and 14% of the examined patients at 3 and 12 months, respectively. The high proportion of survivors without neurological or neuropsychological sequelae confirms that resuscitation from out-of-hospital VF by physician-manned ALS units is beneficial for the patient.

In addition, we found that ACD-CPR significantly increased the chance of obtaining ROSC with an estimated extra 26% saved lives. ACD-CPR also significantly improved the GLS, NIHSS, BI and MMSE scores 3 months after CA with an estimated 14-16% of the range from none to normal function, but no significant effect was seen after 12 months. Neither SAED, bystander CPR, collapse-to-BLS interval nor collapse-to-ALS interval were significantly associated with ROSC or all neurological examinations 3 and 12 months after CA.

Prospective studies with larger numbers of patients are needed to test the results presented here.

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