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# Improved survival after an out-of-hospital cardiac arrest using new guidelines

J. STEINMETZ, S. BARNUNG, S. L. NIELSEN, M. RISOM and L. S. RASMUSSEN
*Department of Anaesthesia, Centre of Head and Orthopaedics, Copenhagen University Hospital, Rigshospitalet, Copenhagen, Denmark.*

**Background:** An out-of-hospital cardiac arrest (OHCA) is associated with a poor prognosis. We hypothesized that the implementations of 2005 European Resuscitation Council resuscitation guidelines were associated with improved 30-day survival after OHCA.
**Methods:** We prospectively recorded data on all patients with OHCA treated by the Mobile Emergency Care Unit of Copenhagen in two periods: 1 June 2004 until 31 August 2005 (before implementation) and 1 January 2006 until 31 March 2007 (after implementation), separated by a 4-month period in which the above-mentioned change took place.
**Results:** We found that 30-day survival increased after the implementation from 31/372 (8.3%) to 67/419 (16%), $P = 0.001$. ROSC at hospital admission, as well as survival to hospital discharge, were obtained in a significantly higher proportion from 23.4% to 39.1%, $P < 0.0001$, and from 7.9% to 16.3%, $P = 0.0004$, respectively. Treatment after implementation was confirmed as a significant predictor of better 30-day survival in a logistic regression analysis.
**Conclusion:** The implementation of new resuscitation guidelines was associated with improved 30-day survival after OHCA.

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**Key words:** Out-of-hospital cardiac arrest; survival; guidelines; chest compression; CPR; emergency medical services; cardiac massage; resuscitation.



PATIENTS with an out-of-hospital cardiac arrest (OHCA) have a poor prognosis, allowing room for improvement. The European Resuscitation Council (ERC) guidelines, published in November 2005, included numerous profound changes in the management of cardiac arrest. The most important changes were that chest compression was given a higher priority and that ventricular fibrillation (VF) should be treated with only one DC-shock, followed by chest compressions and ventilation without checking the rhythm or the pulse. The main purpose of these changes was to reduce no-flow time (1). The aim of our study was to investigate whether the short-term prognosis after OHCA was improved after the implementation of new guidelines. The changes took place in a physician-based emergency medical system where a specialist in anaesthesiology is responsible for the treatment of all OHCA. We hypothesized that the implementation of the 2005 ERC resuscitation guidelines was associated with improved 30-day survival after OHCA.

## Methods

The study was conducted in Copenhagen as an observational cohort study with a 30-day follow-up.

### *Endpoints*

The primary endpoint was 30-day survival after OHCA. Secondary endpoints were Return of Spontaneous Circulation (ROSC) at hospital admission and survival to discharge from hospital.

### *Data collection*

All patients with OHCA treated by the Mobile Emergency Care Unit of Copenhagen (MECU) were included in the following periods: 1 June 2004 until 31 August 2005 (before the implementation period) and 1 January 2006 until 31 March 2007

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(after implementation period). These periods were separated by the time period from 1 September until 31 December 2005 in which the new 2005 ERC guidelines were implemented. An automated chest compression device (AutoPulse®, Zoll Medical Corporation, Chelmsford, MA) was also available after the implementation of new guidelines (2–5). Data concerning the cardiac arrest, pre-hospital treatment and status on admittance to hospital were prospectively registered by the physician manning the MECU and entered into an Access database (Microsoft Corporation; Redmond, WA). Resuscitation data were reported according to the Utstein recommendations (6).

The database was later cross-referenced with the Danish national registry called The Danish Civil Registration System to assess whether patients were alive 30 days after the incident. We used the unique personal identification number, which all Danish citizens are assigned, to locate the patients.

### *Emergency medical services*

Copenhagen is the capital of Denmark. The city covers 97 $km^2$, with a resident population of 593,000, increased by approximately 10% in the daytime. In Denmark, a single emergency telephone number, 112, connects the caller with the emergency dispatch centre (7). In Copenhagen, emergency medical services (EMS) are two tiered as described previously (8). The basic life support (BLS) unit, equipped with two BLS providers and, among other things, an automated external defibrillator (AED), is called out from eight different locations. The MECU is an advanced life support (ALS) unit, on call 24 h a day and 7 days a week, located in the centre of Copenhagen. The MECU is staffed with a consultant in anaesthesiology, intensive care and emergency medicine and a specially trained ALS provider. In case of a presumed cardiac arrest, the BLS unit and the MECU are dispatched simultaneously, and they rendezvous at the incident location. ALS treatment was provided according to the ERC 2000 guidelines before the implementation period and in accordance with the ERC 2005 guidelines after the implementation period (1). The MECU carries various equipment and all drugs and treatment modalities for ALS, and in the period after implementation a chest compression device (Autopulse®) was included. After the initial treatment, the patient was transferred to a hospital in Copenhagen. Throughout both periods of inclusion, mild therapeutic hypothermia was routinely used on 60% of all OHCA patients with ROSC in the emergency department according to the ALS Task Force of the International Liaison Committee on Resuscitation (9). Cooling was initiated at hospital admission, aimed at a core temperature of 33 °C and maintained for 24 h (10, 11).

Response time interval was calculated from the time of the MECU dispatch until arrival of the respective unit at the call location. Pulseless ventricular tachycardia was classified as VF.

### *Statistical analysis*

Continuous data are reported as median with (5–95 percentile) and proportions with (%). Groups were compared using Mann–Whitney's rank sum test (continuous data) and the $\chi^2$-test (proportions). A logistic regression analysis was performed to assess independent predictors of 30-day survival, reported as odds ratios (OR) with 95% confidence intervals. We considered $P$-values $\leq 0.05$ to be statistically significant. Data analysis and statistical evaluation were performed using a commercial statistical package (SAS institute Inc., Cary, NC). We estimated that a sample size of 800 patients would allow us to detect a difference in survival between 13% [before implementation as reported in another study (12)] and 20% (after implementation) with a statistical power of at least 80% at the 5% significance level.

### *Ethics*

The processing of personal data was approved by The Danish Data Protection Agency (J.nr. 2007-41-0531). Because all data were immediately accessible in existing databases, informed consent from patients and approval from the local Ethics Committee were, according to Danish law, not required.

## Results

During the two periods of inclusion, a total of 17,576 patient contacts to the MECU were established (Figs 1 and 2). In total, 791 episodes of OHCA were treated by the MECU. We found that 30-day survival increased significantly after the implementation (8.3% vs. 16.0%, $P = 0.001$) (Table 1). ROSC at hospital admission was obtained in a significantly higher proportion: 23.4% vs. 39.1% (Table 1). The proportion of patients with ROSC at hospital admission who survived 30 days did

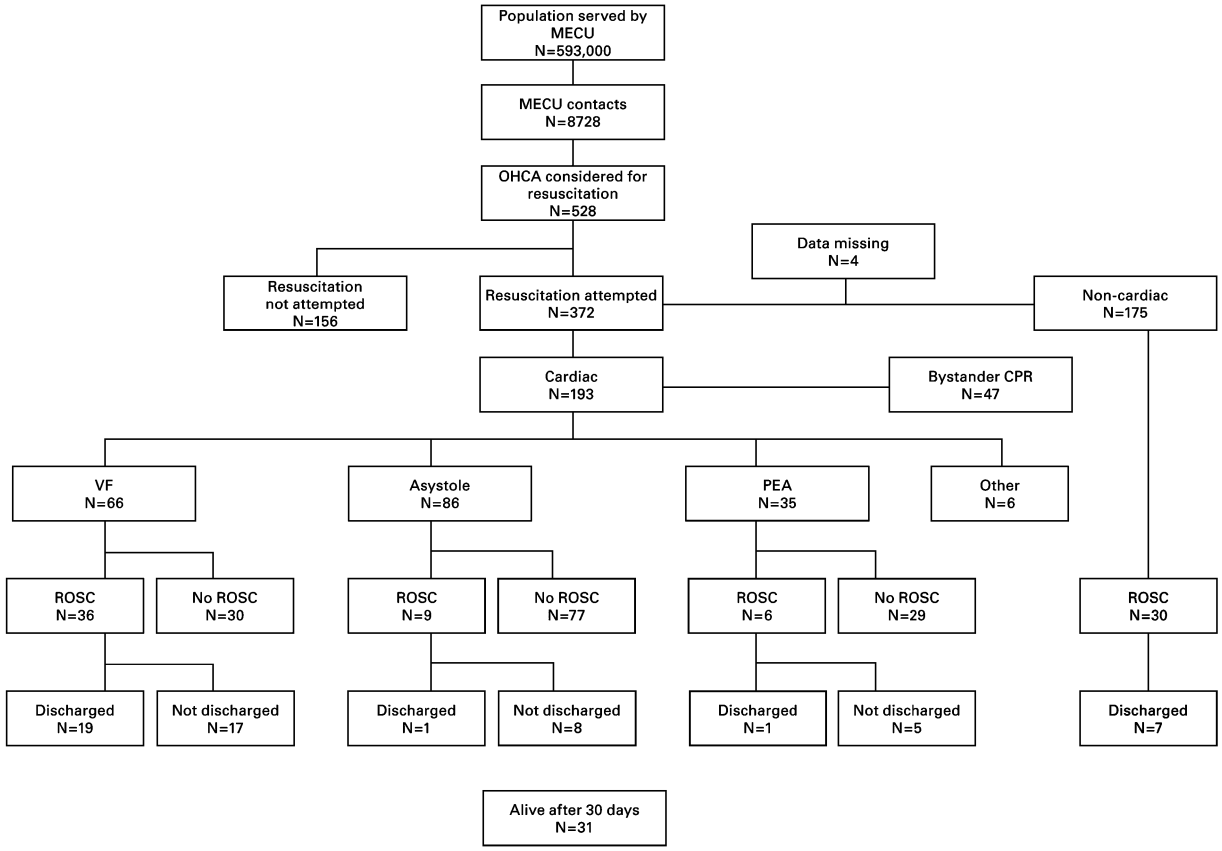


*Fig. 1. Out-of-hospital cardiac arrests (OHCA) in 2004–2005 treated by the Mobile Emergency Care Unit of Copenhagen (MECU) before the implementation of 2005 ERC resuscitation guidelines.*

not change significantly after the implementation, 31/87 = 36% vs. 67/164 = 41%. Discharge from hospital alive was found in 29 (7.9%) patients before and 67 (16.3%) patients after the implementation period, and the corresponding figures for VF, cardiac aetiology, were 19/66 = 28.8% vs. 38/98 = 38.8%, $P = 0.25$ (Figs 1 and 2). No significant difference between the two time periods was found in age, response time interval, primary rhythm observed, suspected aetiology, bystander CPR given or gender (Table 1).

After the implementation, the chest compression device was used in 77 patients, of whom 40 (52.0%) obtained ROSC at admission vs. 124/342 (36.3%) in patients treated without the compression device, $P = 0.01$, but the 30-day survival was not significantly different 10/77 = 13.0% vs. 57/342 = 16.7%, $P = 0.43$.

Logistic regression analysis of a combined dataset from both time periods confirmed that treatment after implementation of new guidelines was significantly associated with a better 30-day survival. The use of an automated chest compression device was associated with worse 30-day survival (Table 2).

During the 4-month period of implementation, 97 patients had OHCA. ROSC was obtained in 23 (23.7%) of these patients and of the 17 (17.5%) patients who were discharged from hospital alive, only 10 (10.3%) were alive after 30 days.

## Discussion

This analysis was undertaken to assess the effects of implementing new resuscitation guidelines in a physician-based emergency medical system. We found improved outcome among patients with OHCA as the 30-day survival was significantly increased from 8.3% to 16.0%. ROSC at admission to hospital as well as survival to discharge from hospital improved significantly after the implementation.

A number of limitations related to this study have to be addressed. First, as it is an observational study analysing changes in resuscitation treatment,

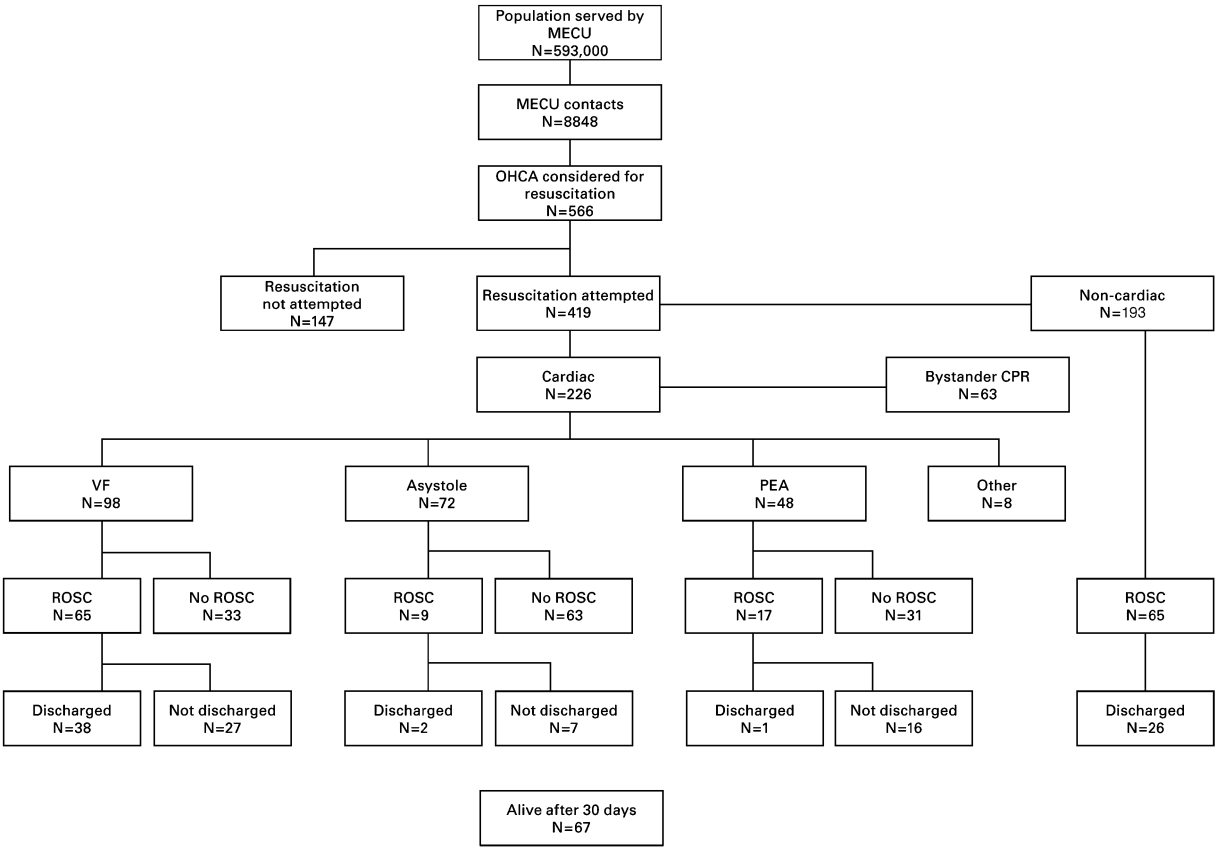


*Fig. 2. Out-of-hospital cardiac arrests (OHCA) in 2006–2007 treated by the Mobile Emergency Care Unit of Copenhagen (MECU) after the implementation of 2005 ERC resuscitation guidelines.*

we are not aware of other changes in the management of OHCA occurring during data collection but during subsequent hospitalisation coronary intervention may has been applied more often as the usage of invasive procedures have been increasing for the past decade (13, 14). However, this can only affect the 30-day survival and cannot explain the improved rate of ROSC at admission to hospital. Furthermore, during the 4-month period of implementation, we found a proportion of ROSC that remained unchanged but a slightly improved 30-day survival (10.3%). This is consistent with our hypothesis.

Another limitation is that this study was neither randomised nor blinded. There tended to be a higher prevalence of VF among OHCA's with cardiac aetiology after the implementation period as it increased from 66/193 = 34% to 98/226 = 43%. This is not statistically significantly different but this factor can contribute to the overall improved outcome although the logistic regression analysis revealed that treatment after the implementation period was an independent predictor of survival. VF was also an independent predictor of survival and survival in VF tended to increase from 19/66 = 29% to 38/98 = 39% (Table 2). We believe that the new guidelines contribute to this improvement in survival among patients with VF and it is remarkable that no improvement was seen in patients presenting with PEA or asystole (Figs 1 and 2).

Resuscitation was attempted in a similar proportion of patients with OHCA in the two periods, 70.5% and 74.0%, respectively (Figs 1 and 2). A slight increase in the number of OHCA's was seen between the two periods but the role of the MECU in relation to dispatchment and treatment of OHCA's has remained unchanged throughout both periods. Another study from Copenhagen published in 2000 found that 8.9% of the patients were discharged alive from hospital and there was a 1-year survival of 7.1%, which is consistent with our data before implementation (15). A randomised study would clearly have offered a better opportunity to obtain comparable groups but a large study including all cases of OHCA may in fact better reflect how an intervention can affect outcome in daily clinical practice. Some data on discharge from hospital and primary rhythms were

*Table 1*

Patients with out-of-hospital cardiac arrest treated by Mobile Emergency Care Unit of Copenhagen before and after implementation of new resuscitation guidelines.

| | Before implementation years 2004–2005 $n = 372$ | After implementation years 2006–2007 $n = 419$ | *P* |
|---|---|---|---|
| Age | 67 (29–89) | 68 (37–90) | 0.59 |
| Male gender | 240 (64.5%) | 273 (65.2%) | 0.89 |
| Response time (min) | 5 (2–10) | 5 (2–10) | 0.41 |
| Cardiac arrest witnessed | 187 (67.8%) | 246 (74.3%) | 0.07 |
| | $n = 276$ | $n = 331$ | |
| Bystander cardiopulmonary resuscitation | 64 (23.9%) | 90 (27.6%) | 0.30 |
| | $n = 268$ | $n = 326$ | |
| Suspected aetiology | | | |
| Cardiac | 193 (68.2%) | 226 (67.5%) | 0.85 |
| Airway obstruction | 11 (3.9%) | 12 (3.6%) | |
| Intoxication | 7 (2.5%) | 14 (4.2%) | |
| Trauma | 3 (1.1%) | 6 (1.8%) | |
| Other | 69 (24.3%) | 77 (22.9%) | |
| | $n = 283$ | $n = 335$ | |
| Primary rhythm: | | | |
| VF | 84 (29.7%) | 122 (36.5%) | 0.07 |
| Pulseless electrical activity | 55 (19.4%) | 77 (23.1%) | |
| Asystole | 136 (48.1%) | 129 (38.6%) | |
| Uncertain | 8 (2.8%) | 6 (1.8%) | |
| | $n = 283$ | $n = 334$ | |
| Return of spontaneous circulation at hospital admission | 87 (23.4%) | 164 (39.1%) | $<0.0001$ |
| Hospital discharge alive | 29 (7.9%) | 67 (16.3%) | 0.0004 |
| | $n = 367$ | $n = 411$ | |
| 30-Day survival | 31 (8.3%) | 67 (16.0%) | 0.001 |

Data are reported as medians with (5–95 percentiles) or numbers (%). Groups were compared using Mann–Whitney's rank sum test and $\chi^2$-test.
VF, ventricular fibrillation.

missing, which is a limitation leaving some uncertainty related to the comparability between the two time periods. On the other hand, the strength of our study is the high quality of the death registration. The Danish Civil Registration System allowed us to obtain the survival status on all Danish patients.

*Table 2*

Predictors of 30-day survival after out-of-hospital cardiac arrest ($n = 791$) treated by Mobile Emergency Care Unit of Copenhagen.

| Predictors of 30-day survival | Odds ratio (95% CI) | *P* |
|---|---|---|
| Bystander cardiopulmonary resuscitation | 3.1 (1.8–5.4) | $<0.0001$ |
| Male gender | 2.3 (1.1–4.6) | 0.02 |
| Treatment after implementation period | 2.5 (1.4–4.6) | 0.002 |
| Cardiac arrest witnessed | 2.5 (1.1–5.4) | 0.02 |
| Use of Autopulse[16] | 0.4 (0.2–1.0) | 0.04 |
| Primary rhythm VF | 5.5 (3.1–9.7) | $<0.0001$ |
| Response time | 1.1 (0.9–1.2) | 0.29 |
| Age above 70 years | 0.4 (0.2–0.6) | 0.0007 |

Data are given as odds ratios with 95% confidence interval (CI) using logistic regression analysis.
VF, ventricular fibrillation or pulseless ventricular tachycardia.

It should not come as a surprise that new guidelines improve treatment, because they are based on research, but it is remarkable that the 30-day survival can be substantially improved, given the moderate number of patients. Nevertheless, it is consistent with other studies (16, 17) that have shown improved outcome after changing the ALS protocol with less focus on defibrillation and more attention towards chest compression, thereby reducing the hands-off time.

We do not know what role the chest compression device played in relation to the overall improvement in survival as this apparatus was only associated with improved ROSC at admission but a significantly worse 30-day survival. The chest compression device was used in only $77/419 = 18\%$ of the cardiac arrests resuscitated after the implementation. From this perspective, we can hardly claim that the Autopulse was fully implemented in our unit.

In conclusion, the implementation of new resuscitation guidelines was associated with an improved outcome after OHCA in a physician-staffed emergency medical system.

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Address:
*Jacob Steinmetz*
Department of Anaesthesia, HOC 4231
Copenhagen University Hospital, Rigshospitalet
DK-2100 Copenhagen
Denmark
e-mail: jacobsteinmetz@dadlnet.dk