Response interval is important for survival until admission after prehospital cardiac arrest

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ABSTRACT

INTRODUCTION: An increasing distance to the nearest hospital must be expected as a result of centralization of acute care at a small number of hospitals. This may have important consequences in emergency situations, such as prehospital or out-of-hospital cardiac arrest (OHCA) where the aim is to obtain return of spontaneous circulation (ROSC), i.e. successful resuscitation. The aim of this study was to describe the impact of response interval on sustained ROSC, i.e. ROSC at hospital admission, after OHCA with presumed cardiac aetiology.

MATERIAL AND METHODS: We included all OHCA calls in which the Copenhagen Mobile Emergency Care Unit (MECU) was involved during the 2002-2008 period. Data were collected prospectively and the primary endpoint was sustained ROSC.

RESULTS: Resuscitation was attempted in 2,678 OHCA cases. Among these, cardiac aetiology was presumed in 2327 cases, and 745 patients (32.0%) achieved sustained ROSC. The mean response interval was significantly shorter for patients who obtained sustained ROSC (370 seconds) than for patients who did not (394 seconds) ($p = 0.015$).

CONCLUSION: A significantly shorter response interval was observed in patients who were successfully resuscitated after out-of-hospital cardiac arrest than in patients who were not successfully resuscitated.

A growing distance to the nearest hospital providing emergency care must be expected in many countries as a result of centralization of acute admission to fewer, larger hospitals. This may have important consequences in emergency situations, such as prehospital or out-of-hospital cardiac arrest (OHCA), where the aim is to obtain return of spontaneous circulation (ROSC), i.e. successful resuscitation. A 10% increase in mortality has been described for each minute that passes without resuscitation during cardiac arrest [1].

The planning of the future prehospital organization will include provision of physician-based emergency care by mobile emergency care units (MECU) in order to provide life-saving intervention. The response interval is defined as the time from receiving the dispatch until the MECU arrives at the scene. The response interval is probably important for the prognosis, but few data elucidate this aspect. Still, a time limit of 15 minutes after a 112-call has been suggested in some places, including Denmark [2].

The aim of this study was to describe the impact of the response interval on sustained ROSC, i.e. ROSC at hospital admission, after out-of-hospital cardiac arrest (OHCA) with a presumed cardiac aetiology.

We hypothesized that a shorter response interval would be seen in patients who were successfully resuscitated after OHCA.

MATERIAL AND METHODS

Data collection

We included all OHCA calls in which the Copenhagen Mobile Emergency Care Unit (MECU) attended and attempted resuscitation during the 2002-2008 period. Data were collected prospectively by the attending physician, documented on a registration sheet and entered into a research database.

The following data were retrieved from the research database: time of received alarm call, time of arrival at the scene, gender, age, reported dispatch diagnosis from emergency dispatch centre, recorded diagnosis code at the MECU, aetiology and initial rhythm. The recorded diagnosis at the MECU may differ from the dispatch diagnosis due to incomplete information, diagnostic error or illness progression.

We followed the Utstein-recommendations [3, 4].

Out-of-hospital cardiac arrest. Model.

ORIGINAL ARTICLE

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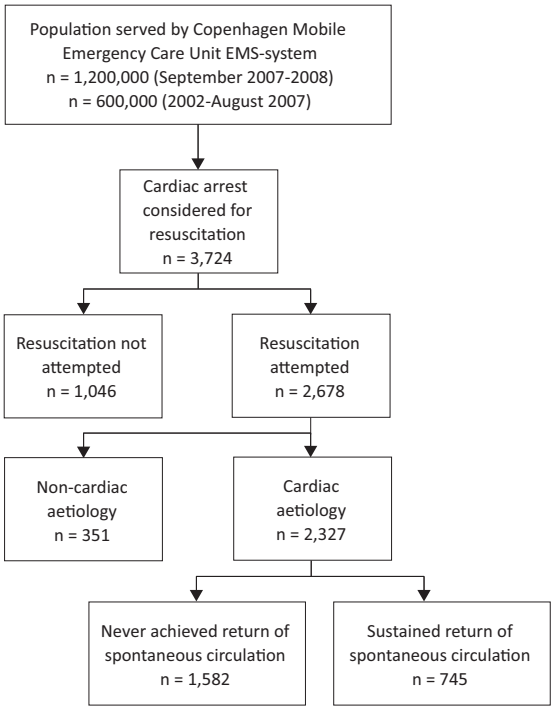
FIGURE 1

Out-of-hospital cardiac arrest at Copenhagen Mobile Emergency Care Unit in Utstein template



EMS = emergency medical services.

Study area and population

Until 1 September 2007, the MECU covered the population of Copenhagen and Frederiksberg municipalities, a total area of 90 km^2. At the end of the data collection period, the MECU served the southern part of the Capital Region of Denmark, corresponding to 1.2 million inhabitants within an area of 675 km^2 [5]. After 1 September 2007, an extra vehicle was located in the western part of the region in the time period 8.30 a.m.-8 p.m. to compensate for the increase in area.

Emergency medical services system

Denmark has a single emergency telephone number (112), which puts the caller into contact with an emergency dispatch centre. The dispatch of emergency vehicles is based on standardized protocols; however, dispatch information is not collected and stored systematically [6].

The emergency medical services (EMS) system is two-tiered with a basic life support (BLS) unit and a advanced life support (ALS) unit, the MECU [7]. The BLS unit is equipped with a defibrillator and manned by two emergency medical technicians.

A specially trained technician mans the MECU along with a physician, who is specialized in anaesthesiology and is an ALS provider. The MECU is equipped with a wide assortment of medicine and equipment for advanced life support.

In case of cardiac arrest and other life-threatening emergencies, the BLS unit and MECU are dispatched simultaneously and rendezvous at the incident location. OHCA is diagnosed by the attending physician who decides on the type of treatment and whether resuscitation should be withheld.

After achieving ROSC, the patient is transferred to a regional hospital. The definition of cardiac arrest and treatments were in accordance with the European Resuscitation Council (ERC) guidelines, and the 2005 guidelines were implemented in the autumn of 2005 [1].

Outcome

The primary analysis consisted in comparing response intervals according to sustained ROSC in patients with OHCA of presumed cardiac aetiology. The response interval was defined as ''time from reception of dispatch diagnosis at MECU to arrival at scene''.

Statistics

Continuous data are reported as means with 95% confidence intervals (CI) or medians with 5-95% percentiles, while categorical data are reported as proportions with 95% CI. We compared response intervals between groups using an unpaired t-test. This analysis was also performed for three separate time periods: 2002 to 2005 (before implementation of the new guidelines), 2006-August 2007 (after implementation of the new ERC guidelines, but before expansion of driving area) and September 2007-2008 (after expansion of the driving area).

Logistic regression analysis was performed to assess independent predictors for sustained ROSC. The following covariates were included in this analysis: response interval, gender, age, reported dispatch diagnosis from emergency dispatch centre, and initial rhythm. We considered p-values < 0.05 statistically significant. Data analysis was performed using SPSS Statistics 18.0 (SPSS Inc., Chicago, Illinois, USA).

RESULTS

Between 1 January 2002 and 31 December 2008, the MECU was dispatched to 3,724 OHCAs (**Figure 1**). Resuscitation was attempted in 2,678 cases, corresponding to 41-53 resuscitation attempts per 100,000 inhabitants per year. Cardiac aetiology was presumed in 2,327, and 745 patients (32.0%) achieved sustained ROSC. Six cases were excluded due to lack of information.

During the entire period, the response interval was significantly longer for patients who did not obtain sus-

tained ROSC (p = 0.015) than for patients who did. The mean response interval was 370 seconds (95% CI: 356-385) in patients who achieved sustained ROSC and 394 seconds (95% CI: 384-404) in patients who did not obtain sustained ROSC (**Figures 2** and **Figure 3**).

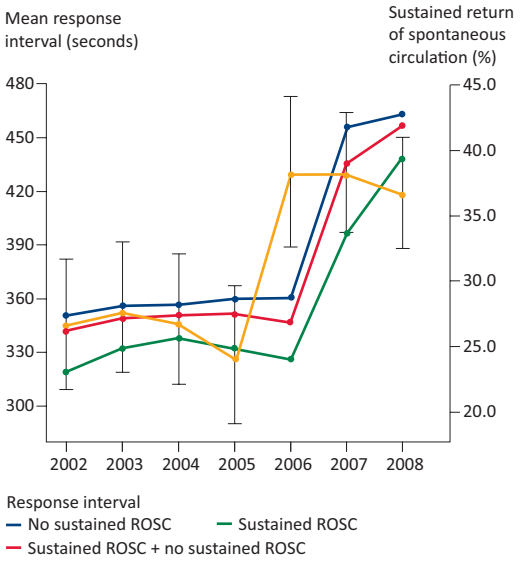
Both the response interval and the sustained ROSC rate increased during the data collection period (Figure 2). The response interval tended to be longer in patients who did not obtain sustained ROSC within all the three pre-defined time periods (2002 to 2005, 2006 to August 2007, and September 2007 to 2008), although this trend was not statistically significant in the last time period.

The mean response interval according to sustained ROSC was 331 seconds (95% CI: 314-348) versus 356 seconds (95% CI: 344-368), 323 seconds (95% CI: 304-342) versus 356 seconds (95% CI: 338-374), and 457 seconds (95% CI: 426-488) versus 487 seconds (95% CI: 465-509) in patients who did and who did not obtain sustained ROSC, respectively, for the three time periods.

Age was lower and the proportion of males was greater among patients who obtained sustained ROSC (**Table 1**) than among patients who did not. For patients with sustained ROSC, the most frequently observed initial rhythm was ventricular fibrillation, while patients with no sustained ROSC most frequently had asystole. Overall, the most frequent dispatch diagnosis was cardiac arrest and there was no significant difference in dispatch diagnosis according to sustained ROSC. Logistic regression analysis revealed that sustained ROSC was significantly associated with the following independent variables: response interval (odds ratio (OR) = 0.965), gender (OR = 1.481), age (OR = 0.985) and initial rhythm (OR = 1.067).

FIGURE 2

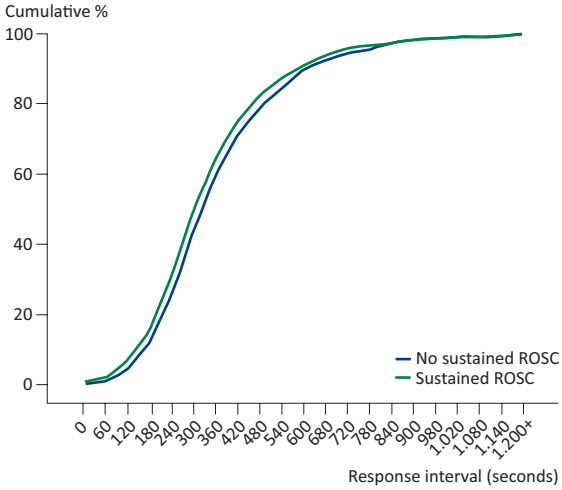
Development in observed mean response interval and in the percentage of patients achieving sustained return of spontaneous circulation after out-of-hospital cardiac arrest at Copenhagen Mobile Emergency Care Unit for the 2002-2008 period.



CI = confidence interval; ROSC = return of spontaneous circulation.

FIGURE 3

Cumulative percentages of sustained return of spontaneous circulation and no sustained return of spontaneous circulation by response interval after out-of-hospital cardiac arrest at Copenhagen Mobile Emergency Care Unit, 2002-2008.



ROSC = return of spontaneous circulation.

DISCUSSION

We found that the response interval was significantly longer for patients who did not obtain sustained ROSC after out-of-hospital cardiac arrest than for patients who did achieve ROSC. The rate of sustained ROSC increased during the data collection period, despite an increase in mean response interval as a result of an expansion of the area covered by our MECU.

The strength of this study is mainly that it is based on a comprehensive, uniformly collected data set that covers a large population. We are aware of factors associated with our design that could have an impact on the results. First of all, we were unable to document whether the cardiac arrest was witnessed and whether bystander cardiopulmonary resuscitation and/or defibrillation were performed. This could have an impact on our results, since these factors are associated with increased survival [8]. Moreover, initial treatment by the BLS unit is not included in the data analysis.

We decided to focus on sustained ROSC rather than long-term survival because we aimed to elucidate prognostic factors in the prehospital setting. Long-term survival, in contrast, depends on post-resuscitation care

TABLE 1

Baseline data for 2,327 patients treated for out-of-hospital cardiac arrest with cardiac aetiology. Copenhagen Mobile Emergency Care Unit, 2002-2008.

	Patients with sustained return of spontaneous circulation (n =745)			Patients with no sustained return of spontaneous circulation (n = 1.582)		
	no. of patients	median (5-95%)	% (95% CI)	no. of patients	median (5-95%)	% (95% CI)
Age, years	–	65 (36-86)	–	–	71 (38-90)	–
Male, %	–	–	71.7 (68.3-74.8)	–	–	61.9 (59.5-64.2)
Response interval, s	–	330 (120-720)	–	–	360 (180-780)	–
Initial rhythm, %						
Ventricular fibrillation	300	–	40.3 (36.8-43.8)	202	–	12.8 (11.2-14.5)
Ventricular tachycardia	28	–	3.8 (2.6-5.4)	11	–	0.7 (0.4-1.2)
Asystole	143	–	19.2 (16.5-22.2)	731	–	46.2 (43.8-48.7)
Pulseless electric activity	225	–	30.2 (27.0-33.6)	267	–	16.9 (15.1-18.8)
Unknown	49	–	6.6 (5.0-8.6)	371	–	23.5 (21.4-25.6)
Dispatch diagnosis, %						
Cardiac arrest	373	–	50.1 (46.5-53.7)	769	–	48.6 (46.2-51.1)
Heart attack	81	–	10.9 (8.8-13.3)	114	–	7.2 (6.0-8.6)
Unconscious	181	–	24.3 (21.4-27.5)	369	–	23.3 (21.3-25.5)
Possible death	8	–	1.1 (2.1-5.5)	104	–	6.6 (5.5-7.9)
Miscellaneous	102	–	13.7 (11.4-16.4)	226	–	14.3 (12.7-16.1)

CI = confidence interval.

after hospital admission, including intensive care, therapeutic hypothermia, and percutaneous coronary intervention, as well as any subsequent medical therapy and other treatment of underlying diseases [9].

A number of changes occurred during the data collection period. New guidelines on OHCA treatment were implemented at the MECU, and the proportion of OHCA patients who were treated has risen in recent years [10, 11]. The attending physician today simply decides to attempt resuscitation more frequently than in the past. Intuitively, this would adversely affect the observed sustained ROSC rates as a result of inclusion of patients with a relatively poor prognosis, but that does not seem to be the case. We are unable to say whether the difference in response interval is related to the decision by the attending physician, who may be less prone to continue resuscitation attempts in instances where the response interval is prolonged.

Finally, the mean response interval increased because of organisational changes in our region. Nevertheless, we found the same pattern in separate subgroup analyses covering each of the three time periods in which these factors were unchanged. The mean response interval was approximately 30 seconds longer in patients where sustained ROSC was not obtained.

Frederiksson et al [12] summarized the work of several studies in which sustained ROSC was recorded for patients having witnessed cardiac arrest with presumed cardiac aetiology. In eight of these studies, including Amsterdam and New York City, sustained ROSC rates between 13-28% were found. Furthermore, two other studies, performed in Bonn and Helsinki, showed higher sustained ROSC rates than ours, 53% and 51%, respectively versus the 32% of our study. We did not collect data allowing us to differentiate with regard to witnessed or unwitnessed cardiac arrest. Therefore, our sustained ROSC rate may have been underestimated compared with these studies. Other important differences could lie in the manning and in demography, which possibly explain the observed differences in sustained ROSC rates.

A higher probability of ROSC has been found in two-tiered EMS systems with both BLS and ALS units [10, 13]. A physician may initiate advanced medical therapy and, in addition, physicians can decide to withhold treatment in cases deemed hopeless. In contrast, BLS units must always attempt resuscitation according to local protocols and the ROSC rate may not be greater in patients treated by ALS than in BLS units [14]. One explanation for this may be that skilled physicians are able to temporarily obtain ROSC in patients with a poor prognosis. This may, however, be associated with a poor long-term survival.

High sustained ROSC rates have been reported in studies from Bonn and Helsinki, where response intervals were short with a median of five minutes and a mean of seven minutes, respectively. This is quite similar to the median 330-360 seconds we found in our study. Sustained ROSC rates of 16% and 21% have been found in New York City and St. Etienne, respectively, where the median response intervals were 9.9 minutes and 13 minutes. In New York City, treatment was further delayed due to a high number of tower blocks. Several time-consuming factors are not included in the reported response intervals for many studies. A significant amount of time can be spent on contact with the dispatch

centre, communication between dispatch centre and the MECU, and also on initiation of treatment after arrival at the scene. The calculated and reported response intervals should therefore be considered minimum values. The validity of the term ''response interval'' could be enhanced considerably by registering and including all elements, making it cover the entire time period from the call is received at the dispatch centre until the MECU encounters the patient.

Differences in the manner in which the response interval is registered in the various EMS systems, manually or automatically, also contribute to uncertainty when comparing with other studies.

Another aspect is related to the fact that the response interval considered in this study is related to the MECU as it does not describe when the BLS initiates treatment.

It is important to realise that the end-point of sustained ROSC only describes the situation at hospital admission and that we did not assess survival to discharge, cerebral performance category or quality of life. Achievement of ROSC on hospital admission is, nevertheless, a precondition for further diagnostics and treatment.

The significant difference in response interval according to sustained ROSC shows that response interval is of importance. The future prehospital organization should therefore consider this aspect.

CONCLUSION

A significantly shorter response interval was observed in patients who were successfully resuscitated after out-of-hospital cardiac arrest than in patients who were not successfully resuscitated after out-op-hospital cardiac arrest.

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CONFLICT OF INTEREST: *Søren Loumann Nielsen* held a paid lecture about resuscitation for Zoll on 2 June 2008.

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