Clinical Paper

Good outcome in every fourth resuscitation attempt is achievable—An Utstein template report from the Stavanger region

Thomas Werner Lindner, Eldar Søreide, Odd Bjarte Nilsen, Mathiesen Wenche Torunn, Hans Morten Lossius

Aim of the study: Out-of-hospital cardiac arrest (OHCA) is a major cause of death in the western world. We wanted to study changes in survival over time and factors linked to this in a region which has already reported high survival rates.

Methods: We used a prospectively collected Utstein template database to identify all resuscitation attempts in adult patients with OHCA of presumed cardiac origin. We included 846 resuscitation attempts and compared survival to discharge with good outcome in two time periods (2001–2005 vs. 2006–2008).

Results: We found no significant differences between the two time periods for mean age (71 and 70 years (p = 0.309)), sex distribution (males 70% and 71% (p = 0.708)), location of the OHCA (home 64% and 63% (p = 0.732)), proportion of shockable rhythms (44% and 47% (p = 0.261)) and rate of return of spontaneous circulation (38% and 43% (p = 0.136)), respectively. Bystander cardiopulmonary resuscitation (CPR), however, increased significantly from 60% to 73% (p < 0.0001), as did the overall rate of survival to discharge from 18% to 25% (p = 0.018). In patients with a shockable first rhythm, rate of survival to discharge increased significantly from 37% to 48% (p = 0.036). In witnessed arrest with shockable rhythm survival to discharge increased from 37% to 52% (p = 0.0105).

Conclusion: Overall, good outcome is now achievable in every fourth resuscitation attempt and in every second resuscitation attempt when patients have a shockable rhythm. The reason for the better outcomes is most likely multi-factorial and linked to improvements in the local chain of survival.

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1. Introduction

Every year, emergency medical system (EMS) personnel attempt to resuscitate approximately 500,000 out-of-hospital cardiac arrest (OHCA) victims in Europe and North America.1-3 Substantial variations in short- and long-term survival have been reported.2,4,5 Although differences in bystander cardiopulmonary resuscitation (CPR) rates and time until defibrillation may explain some of the differences, the large variations in survival rates are still not fully understood.5 To improve the local chains of survival, the European Resuscitation Council (ERC), as part of the International Liaison Committee on Resuscitation (ILCOR), have developed internationally recognized guidelines on how to treat OHCA, and the guidelines are revised on a regular basis.6 The Utstein template for uniform data reporting after OHCA has also been revised to allow better comparisons of different EMS systems reporting of OHCA incidence, return of spontaneous circulation (ROSC) and survival rates.4,5,7-9

In the late 1990s, high survival rates after OHCA were reported from the Stavanger region.7,10 Since then we have continued our quality improvement process focusing on bystander CPR, prehospital care as well as the other parts of the chain of survival.7,11-13 We felt it would be of interest to study changes in OHCA survival in our community and therefore used a prospectively collected, population-based, Utstein template OHCA database to study survival and factors linked to survival in adult patients.
with OHCA of presumed cardiac origin in the time period 2001–2008.

2. Materials and methods

2.1. The EMS and Stavanger University Hospital

During the study period from January 1, 2001 to December 31, 2008 the population in the studied region (5700 km²) increased from approximately 273,000 inhabitants to approximately 314,000 inhabitants. Stavanger University Hospital (SUH) is the only receiving hospital for patients after OHCA. The Emergency Dispatch Centre (EDC) at SUH coordinates 18 ambulance units and one hospital-based, anaesthesiologist-manned rapid response unit using a helicopter or car as well as general practitioners (GPs) on call in the local communities. All ambulances are staffed with at least one advanced life support (ALS)-certified paramedic. The resuscitation guideline changes were implemented shortly after their approval. The implementation process of the 2005 guidelines included a training period of some weeks. In this period both guidelines may have been used, but after this only the new guidelines were used as a standard. The Norwegian ALS algorithm from 2000 was similar to the ERC guidelines from 2000 while the ALS algorithm from 2005 differed from the ERC guidelines. The Norwegian ALS algorithm recommended time loops of 3 min duration between rhythm analyses and defibrillation attempts, with pulse control performed 1 min after heart rhythm analysis followed by the administration of 1 mg adrenalin iv if there was no palpable pulse present.

The EDC is reached by one nationwide alarm telephone number and dispatch is criteria-based. Throughout the whole study period, the EDC instructed the calling bystander to start CPR, including mouth-to-mouth ventilations. In cases of presumed OHCA, the EDC activates a response consisting of one or two ambulances, the anaesthesiologist-manned rapid response unit and the local GP on call. There were no systematic changes in this response pattern in the study period. The EDC always tried to get at least one doctor and one ambulance unit to the scene. If the incident was not primarily identified as OHCA by the EDC, the rapid response unit was called out later. Resuscitation attempts not leading to sustained ROSC were as a rule terminated on scene, and transportations to the hospital with on-going CPR were rare.

Apart from an increased number of fire brigades equipped with automated external defibrillators (AED) acting as first responders, there were no major organizational changes to this response system during the study period. The collaborations between fire brigades and the EMS began in 2000 and had reached 17 units in 2008.

Public education in basic CPR has been focused on in Norway both through training of health personnel and lay people in the school system and voluntary organizations. Standard courses in basic CPR are offered and encourage the public to use public access AEDs (PAD). PADs were first provided in 2001, and approximately 100 PADs were available in the study area in 2008. PADs were typically placed in large businesses, public buildings, schools and shopping malls. The EDC does not, however, have alerting routines for PAD locations.

In-hospital treatment for OHCA survivors has been expanded to include therapeutic hypothermia (TH) as part of post resuscitation intensive care in all unconscious patients from 2002 and urgent percutaneous coronary intervention (PCI) in STEMI from 2004. Prior to the implementation of TH, comatose survivors of OHCA were treated with 2–3 days on mechanical ventilation before prognostication and possible withdrawal of active treatment.

2.2. Patient inclusion and data collection

Since 1996, all EMS missions for an OHCA have been registered in the hospital-run Utstein registry. The present study accessed all prospective collected datasets of individuals 18 years and older between January 1, 2001 and December 31, 2008. We included patients with OHCA from presumed cardiac origin according to the Utstein definition without obtaining post mortems. The following two groups were excluded from further analysis: patients with OHCA of non-cardiac origin and patients without resuscitation attempts (Fig. 1). The latter situation occurred when somebody called the EDC, but the EMS did not perform medical measures such as airway assistance, chest compressions, drug administration, intubation or defibrillation.

Eight hundred forty-six patients with OHCA of presumed cardiac origin for whom resuscitation was attempted were included in the present study (Fig. 1). We compared two time periods (2001–2005 vs. 2006–2008). In the first time period, the 2000 ERC resuscitation guidelines were used for CPR. TH and emergency PCI were successively implemented. In the 2006–2008 time period only the 2005 resuscitation guidelines with Norwegian alterations were used and TH and emergency PCI had become standard practice.

Utstein template data were registered separately by both the ambulance and the rapid response unit. For quality assurance, data were cross-checked before being entered in the study database. Missing data for each performed analysis are noted in Section 3. Good outcome in survivors were assessed using the Cerebral Performance Category (CPC) 1–2. The Utstein template database was approved for scientific use nationally and locally by the Norwegian Social Science Data Service, the Regional Committee for Research Ethics and the Central Office for National Registration.

2.3. Statistical analysis

The data were entered into a FilemakerPro9 database (FileMaker, Inc.; USA), and SPSS 15.0 (SPSS, Inc.; USA) was used for statistical analysis. Figures were constructed using SPSS 15.0 and Microsoft® Office Excel 2003 (Microsoft Corporation, USA). We used the chi-square test to examine differences in proportions for categorical variables. For frequencies less than 5, Yates correction was employed. To examine between-group differences the independent-samples t-test was conducted for age and the
Table 1
Demographic overview of OHCA patients in the two time periods studied (n = 846).

<table>
<thead>
<tr>
<th>Time period</th>
<th>Time period</th>
<th>p-Value</th>
<th>Missing data as number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age year/ mean (SD) (n)</td>
<td>71 (15) (555)</td>
<td>70 (15) (291)</td>
<td>0.309</td>
</tr>
<tr>
<td>Male sex (%) (n)</td>
<td>70% (633)</td>
<td>71% (213)</td>
<td>0.708</td>
</tr>
<tr>
<td>Witnessed OHCA (%) (n)</td>
<td>77% (414)</td>
<td>74% (221)</td>
<td>0.263</td>
</tr>
<tr>
<td>EMS witnessed OHCA (%) (n)</td>
<td>11% (68)</td>
<td>8% (28)</td>
<td>0.601</td>
</tr>
<tr>
<td>Bystander CPR (%) (n)</td>
<td>60% (320)</td>
<td>73% (217)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Bystander CPR + witnessed (%) in all patients (n)</td>
<td>47% (261)</td>
<td>55% (160)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Bystander CPR + Non witnessed (%) in all patients (n)</td>
<td>11% (61)</td>
<td>16% (47)</td>
<td>0.152</td>
</tr>
<tr>
<td>Location OHCA (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>64%</td>
<td>63%</td>
<td>0.732</td>
</tr>
<tr>
<td>Public/other</td>
<td>32%</td>
<td>36%</td>
<td>0.453</td>
</tr>
<tr>
<td>EMS</td>
<td>3%</td>
<td>2%</td>
<td>0.264</td>
</tr>
<tr>
<td>(n)</td>
<td>(554)</td>
<td>(291)</td>
<td></td>
</tr>
<tr>
<td>EMS response time in minutes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (IQR)*</td>
<td>8 (5–11)</td>
<td>9 (6–13)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

* IQR = Interquartile range.

Table 2
Comparisons of ROSC, survival to discharge and good cerebral outcome (CPC 1–2) rates in the two time periods (2000–2005 vs. 2006–2008) studied.

<table>
<thead>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>All rhythms (n)</td>
<td>555</td>
<td>291</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROSC (%) (n)</td>
<td>38% (211)</td>
<td>43% (126)</td>
<td>0.136</td>
<td>0</td>
</tr>
<tr>
<td>Survival to discharge (%) (n)</td>
<td>18% (99)</td>
<td>25% (72)</td>
<td>0.018</td>
<td>0</td>
</tr>
<tr>
<td>CPC 1–2 (%) in all survivors (n)</td>
<td>84% (83)</td>
<td>97% (70)</td>
<td>0.010</td>
<td>9</td>
</tr>
<tr>
<td>1 Year survival (%) (n)</td>
<td>14% (75)</td>
<td>22% (64)</td>
<td>0.040</td>
<td>0</td>
</tr>
<tr>
<td>Shockable rhythms (n)</td>
<td>237</td>
<td>136</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROSC (%) (n)</td>
<td>65% (155)</td>
<td>66% (90)</td>
<td>0.879</td>
<td>0</td>
</tr>
<tr>
<td>Survival to discharge (%) (n)</td>
<td>37% (87)</td>
<td>48% (65)</td>
<td>0.036</td>
<td>0</td>
</tr>
<tr>
<td>CPC 1–2 (%) in survivors of shockable rhythms (n)</td>
<td>87% (76)</td>
<td>99% (64)</td>
<td>0.041</td>
<td>7</td>
</tr>
<tr>
<td>1 Year survival (%) (n)</td>
<td>29% (69)</td>
<td>43% (60)</td>
<td>0.005</td>
<td>7</td>
</tr>
</tbody>
</table>

Mann–Whitney–U-Test for the EMS response time. Multivariate logistic regression analysis correcting for age, witnessed OHCA, bystander CPR, time period, shockable rhythm and EMS response time was used to examine differences in both ROSC and survival to discharge.

Two-sided p-values less than 0.05 were considered statistically significant.

3. Results

In the 846 resuscitation attempts studied, age, gender distribution, OHCA location, proportion of OHCAs that were witnessed, and first reported heart rhythm did not differ significantly between the two time periods (2001–2005 vs. 2006–2008), but median EMS response time increased significantly from 8 to 9 min (Tables 1 and 2). The number of patients receiving bystander CPR increased from 60% to 73% (p = 0.0001) (Table 1). Bystander CPR in the subgroup of OHCA patients with witnessed OHCA increased from 47% to 55% (p = 0.0001) (Table 1).

Sixty-five patients were admitted to hospital with ongoing resuscitation. 12 achieved ROSC, but no one survived to discharge.

The overall ROSC rate was 40% and did not change over time (Table 2). The overall survival to discharge and 1-year survival increased significantly from 18% to 25% (p = 0.018) and 14% to 22%, respectively (p = 0.040) (Table 2).

Overall 44% of the OHCA victims presented with a shockable rhythm. The rate of shockable rhythm remained unchanged throughout the study period; 43% vs. 47% (p = 0.261). ROSC rates in patients with shockable rhythms also remained unchanged (66%) during the two study periods (Table 2), while survival to discharge and 1-year survival increased significantly from 37% to 48% (p = 0.036) and 30% to 43% (p = 0.005), respectively (Table 2). In this patient group, good cerebral outcome (CPC 1–2) upon discharge also increased from 87% to 99% (p = 0.041) (Table 2). Survival to discharge and 1-year survival improved significantly (p = 0.0105 and p = 0.0005) in witnessed OHCA with shockable rhythm in the time period 2006–2008 (Fig. 2). In OHCA victims with witnessed arrest and shockable rhythm who received bystander CPR, 52% of patients survived to discharge in the time period 2006–2008 (Fig. 2).

Table 3
Factors associated with ROSC and survival to discharge in OHCA of presumed cardiac origin (n = 747).

<table>
<thead>
<tr>
<th></th>
<th>ROSC</th>
<th>Survival to discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds ratio</td>
<td>95% confidence interval</td>
</tr>
<tr>
<td>Shockable rhythm vs. non-shockable rhythm</td>
<td>6.00</td>
<td>4.20–8.56</td>
</tr>
<tr>
<td>Witnessed arrest vs. non-witnessed arrest</td>
<td>2.90</td>
<td>1.82–4.62</td>
</tr>
<tr>
<td>Bystander CPR vs. no-bystander CPR</td>
<td>1.21</td>
<td>0.83–1.76</td>
</tr>
<tr>
<td>Time period 2006–2008 vs. Time period 2001–2005</td>
<td>1.31</td>
<td>0.92–1.88</td>
</tr>
<tr>
<td>EMS response time (one additional minute)</td>
<td>0.99</td>
<td>0.95–1.00</td>
</tr>
<tr>
<td>Age (one additional year)</td>
<td>0.99</td>
<td>0.98–1.01</td>
</tr>
</tbody>
</table>
Fig. 2. Distribution and survival of witnessed and non-witnessed OHCA of presumed cardiac origin with and without a shockable rhythm in the two time periods compared (2000–2005 vs. 2006–2008). n.s. = non significant.

The multivariate analyses revealed that the time period from 2006 to 2008 was associated with an improved survival to discharge (odds ratio (OR) 1.65), as were witnessed OHCA (OR 2.86), bystander CPR (OR 1.87) and shockable rhythm (OR 14.76) (Table 3). On the other hand, increased EMS response time and older age were associated with reduced odds ratios for survival to discharge (Table 3).

Based on the last 3 years of the study period, the OHCA incidence in our region was approximately 38/100,000 inhabitants.

4. Discussion

After the introduction of the 2005 CPR guidelines and implementation of major treatment changes, such as post-resuscitation TH and PCI, we experienced a significant improvement in overall survival to discharge (25%) in resuscitation attempts of OHCA of presumed cardiac origin in the time period 2006–2008. During the same time period, the proportion of OHCA survivors with good cerebral outcome (CPC 1–2) increased significantly to 97%. For the group of OHCA victims with a witnessed arrest and a shockable rhythm, survival to discharge with good cerebral outcome was obtained in every second resuscitation attempt in the latter period.

Although our study design does not allow a specific analysis of which factors contributed the most, our results indicate a few possible explanations. The rate of shockable rhythm remained unchanged throughout the study period, but it was lower than previously reported in our region and therefore cannot explain the outcomes. This decline in shockable rhythms also matches other reported results. The mean age (70 years) of our patients remained the same throughout the study period and was slightly higher than recently reported by others. Therefore, reduced age cannot explain the improved survival found in our study.

It has previously been shown that an increase in bystander CPR leads to an increase in survival to discharge. The rate of bystander CPR was 73% in the latter time period in our study. We think this is a major reason for the improved outcomes. Bystander CPR may preserve the shockable rhythm until the first defibrillation and ensure minimal cerebral circulation. The increase in bystander CPR is most likely the result of ongoing national and local focus on layperson CPR training. This may be of particular importance, as we noticed increased EMS response times. The increase in EMS response time is most likely due to a rise in traffic during the 8-year study period.

A higher availability of PADS may have increased the probability that OHCA victims received early defibrillation. We were not able to extract specific data on the use of first responder AED or PAD from our database. This could be considered a limitation to our study. However, the first responders were considered part of the total EMS response, and although they may have ensured earlier defibrillation in some cases, we do not think that this measure alone can explain the improved outcomes.

The impact of ALS procedures on OHCA survival is still debated. The first time period examined may have included a short time period where both the 2000 and the 2005 guidelines were used, but the second time period included only patients where the 2005 resuscitation guidelines with Norwegian alterations were used. Positive effects of the 2005 resuscitation guidelines on survival have been demonstrated in populations from Denmark and the
United States,21 but were not found in studies from New Zealand26 and Netherlands, France and Norway.22–24 The varying survival rates reported show the challenge in comparing different EMS systems with varying response factors and post resuscitation treatments. We do not claim that the increase in survival found in our study is due to the implementation of the 2005 resuscitation guidelines alone, but acknowledge that a combination of factors most likely was of importance. Still, the quality of CPR is important during ALS. Minimal hands-off time and correct compression depth and frequency must be maintained.6 We have previously reported good quality CPR over time in a simulated OHCA situation35 involving double ambulance crews. The dedication to provide high-quality CPR may therefore have contributed to the improved survival.

ROSC rate did not change during the study period but survival to discharge did. Further, 97% of our surviving patients obtained a CPC of 1 or 2 in the latter period. This strengthens the likelihood that changes in post-resuscitation care contributed to the increased survival. We implemented post-cardiac arrest TH in 2002 and post-cardiac arrest PCI in 2004.11,12 The full impact of TH was maybe first reached in the latter time period of the study, although our study design made it impossible to determine the exact contribution of TH or PCI to the improved outcomes in the population as a whole. Further, some patients with an indication may not have received the treatments, but previous studies from our system indicate high implementation rates.11,12

We think that our focus on all parts of the local Chain of Survival, as suggested by Rea and Lange in their review where they named this “the community based approach to resuscitation”,36 is what may have caused the significant improvements.

5. Limitations

There are many limitations to a registry-based study like ours, including those listed above, regarding the contribution of the various factors to the overall improved overall outcomes. To ensure data quality, one designated research nurse was continuously collecting and cross-checking data entries from different sources to reduce uncertainty and missing data.

The calculation of survival to discharge rate depends on the population used as the denominator. Decreasing the denominator could have inflated the survival rates. However, we only excluded patients for whom such resuscitation measures as airway assistance, chest compressions, drug administration, intubation or defibrillation were not performed. When we compared the way we excluded resuscitation attempts and patients from our analysis to the exclusions in similar recent studies, we found no discrepancies that could explain our more positive results.1,2,5 The most common reason for not starting resuscitation was obvious signs of death. Presumed OHCA missions to which the EMS responded, but without starting resuscitation, may reflect the EDC alarm accuracy and the caller’s uncertainty. The calculated incidence of 38 OHCA/100,000 inhabitants in our population was slightly lower than previously reported from this region,7 but is still close to the average for the Norwegian population.8 A recent meta analysis reported a mean incidence of 54.6 OHCA/100,000 inhabitants,3 with a standard deviation of 26. Altogether, we see no reason to believe our results are due to selective reporting.

Due to lack of data, we could not include co-morbidity and chronic medical treatment as factors in the multivariate analysis. Because co-morbidity has been shown to be an important factor related to long-term survival this is an obvious limitation in our study.7 More studies are needed to fully elucidate the interaction between co-morbidity, possible genetic factors and survival in OHCA victims.

Similar to other studies, we only used a crude measure of good cerebral outcome (CPC 1–2).25,37 There may therefore have been differences in the quality of outcome that this study could not detect. These aspects of post-resuscitation care should also be examined further.

6. Conclusion

In this study of OHCA of presumed cardiac origin comparing the time periods from 2001 to 2005 with 2006 to 2008, the overall survival to discharge increased to 25% in the latter period. In the 2006–2008 time period, every second resuscitation attempt in patients with a witnessed arrest and a shockable rhythm resulted in survival to discharge with good cerebral outcome. Our results support the notion that all aspects of the chain of survival are important when trying to improve resuscitation outcomes.

Conflicts of interest statement

The authors declare no conflicts of interest.

Acknowledgments

The authors would like to thank Astrid Våga and Kristian Lexow for their help with data collection, and Svein Arne Hapes for leading the way as the medical director of the EMS system in the Stavanger region. We would also like to thank all the paramedics, nurses, doctors and other allied health professionals at SUH for their relentless work to further improve survival in cardiac arrest victims inside and outside the hospital.

References

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