Out-of-hospital circulatory arrest: factors determining the outcome Amsterdam resuscitation study (ARREST) 2 and 3

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Chapter 6
Advanced cardiopulmonary resuscitation performance after out-of-Hospital cardiac arrest: Does it improve survival?

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Abstract

This study analyzed the influence on survival of the last two links of the chain of survival: early defibrillation and early Advanced Life Support (ALS). Included were all witnessed arrests where EMS personnel attempted resuscitation from the ARREST database. Defibrillation, ALS interventions, and time intervals were analyzed in relation to survival. From the 1087 included patients, 144 (13%) survived to discharge. Eighty-three patients did not require ALS procedures to restore spontaneous circulation (ROSC), resulting in a high survival rate (84%). When delay to defibrillation increased the chance to survive declined rapidly, especially when no bystander performed basic life support. The chance to achieve ROSC occurred mainly after the first three defibrillator shocks. When ALS was needed extended, delay resulted in a decreased survival for patients with and without a shockable initial rhythm. We found that ALS procedures had beneficial effect compared to patients where EMS personnel could not achieve ALS treatment. After defibrillation, endotracheal intubation is the most important treatment of any circulatory arrest. Although ROSC was still achieved after 90 minutes of ALS measures, survival diminished to nihil after 25 minutes. It is difficult to proof that ALS is a necessary treatment during resuscitation since the results were confounded by indication bias. To measure the effect of ALS one should consider the need for ALS and the time to the start of ALS performance. When ALS is needed, its delay leads to a markedly reduced and not performing ALS was associated with the worst survival. Prolonging ALS measures over 25 minutes seemed of limited value for out-of-hospital adult cardiac arrests. Early ALS remains a valuable link in the chain of survival.

1. Introduction

Defibrillation and Advanced Life Support (ALS) considered two separate links in the Chain of Survival.\(^1\) Defibrillation has proved to be the most important life-saving procedure for patients with a shockable initial heart rhythm.\(^2\)\(^3\) But other ALS measures never proved to be a survival improving treatment.\(^4\) Nevertheless, it is considered an essential part of resuscitation. One study reported a survival of 2% of patients with ventricular fibrillation treated by ambulance personnel who were trained to perform basic life support (BLS) and to defibrillate only.\(^5\) This suggests that the contribution of ALS procedures might improve survival.

The objective of this study was to separately analyze the effect of defibrillation and ALS procedures on survival, for patients with and without a shockable initial rhythm.

2. Patients and Methods

2.1. Study design

For this analysis we used patients from the database of the Amsterdam Resuscitation Study. The design of this study is published earlier in detail.\(^6\) In brief, the database provided information about all consecutive out-of-hospital cardiac arrests between June 1, 1995 and August 1, 1997. Specially trained research personnel at the scene ensured an accurate registry according to the Utstein recommendation.\(^7\) For this analysis we selected patients with a witnessed arrest and in whom EMS personnel attempted resuscitation. All required ethics committees approved the study.

The study was executed in Amsterdam and its surrounding areas, populated by 1.3 million people and served by a single tiered emergency medical service (EMS) system. One central dispatch center dispatch seven ambulance services. In case of a resuscitation attempt always two ambulances are directed to the scene. All ambulances are staffed with a paramedic and a driver qualify to perform defibrillation and ALS activities, which include endotracheal intubation,
intravenous administration of medication, according to a national protocol based on the ERC guideline.  

2.2. Definitions

A cardiac arrest was when a victim was unconscious and pulseless confirmed by EMS personnel. An unnatural cause of the arrest was trauma, drowning, suicide or intoxication. Shockable rhythms were initial rhythms (ventricular fibrillation or pulseless ventricular tachycardia) treated with a defibrillatory shock by EMS personnel. Unless specially stated, all time intervals are measured from the moment of collapse. The time to call was the interval to the moment the call entered the dispatch center. The time to EMS arrival at the patient’s side was the interval to the power-on of the defibrillator. Time to shock was the interval to the first defibrillatory shock. ALS interventions were endotracheal intubation and intravenous drug administration. Time to ALS was the interval to the first ALS intervention. ‘ALS not needed’ were cases where a spontaneous circulation returned before ALS efforts were initiated. ‘ALS not performed’ were those cases where ALS interventions were attempted by EMS personnel, but could not be accomplished. Duration of ALS measures was defined as start of ALS to the time of definitive ROSC. Definitive ROSC was not discontinued by re-arrest until hospital admission. Endpoints of this study were return of spontaneous circulation (ROSC) and survival, defined as discharged alive from the hospital.

![Figure 1](image-url)  

Figure 1. The histogram demonstrates survival in relation to the time interval from collapse to the first defibrillatory shock for patients with and without BLS before arrival of EMS personnel. Survival declined rapidly when the delay to the first defibrillatory shock increased, especially when no bystander started BLS before defibrillation. There were no patients with BLS when the first defibrillatory shock was delivered within 2 minutes.
2.3. Statistical methods

The relation to the number of defibrillatory shocks and ROSC was calculated in cumulative proportions. All ALS interventions and ALS delays categorized in time intervals of four minutes were related to survival and expressed as odds ratios (OR) with 95% confidence interval (CI). The relation of duration of ALS measures on ROSC and on survival was calculated in cumulative proportions.

3. Results

3.1. Study population

For this analysis we included 1087 witnessed circulatory arrests. In 47 cases there was an unnatural cause. Ten patients with a natural cause were younger than 18 years. The mean age of the patients was 63 years (range: 0-96), 813 (75%) were men. In 167 (15%) cases EMS personnel were present the moment the patient collapsed, from the remaining 920 patients 490 (53%) received BLS prior to the arrival of the EMS. Of the included patients, 578 (53%) had a shockable initial rhythm and 509 (47%) had a nonshockable initial rhythm.

3.2. Defibrillation, delay and outcome

For 578 patients with a shockable initial rhythm survival declined rapidly, when the time to the first defibrillatory shock increased (Figure 1). This effect was even more pronounced when no bystander performed BLS before defibrillation.

In 284 patients (49%) with a shockable initial rhythm, return of spontaneous circulation (ROSC) was achieved after defibrillation. It took at least three shocks, including shocks for refibrillation to achieve ROSC in 189 patients, 67% of all patients that eventually had ROSC (Figure 2). The chance of ROSC diminished rapidly when the number of defibrillatory shocks increased. Only nine patients (3%) needed more than 9 shocks to achieve ROSC.

Figure 2. The histogram presents the cumulative proportion of patients where spontaneous circulation was restored (ROSC) in relation to the increased number of defibrillatory shocks. There is a rapid decrease in the chance to achieve ROSC when the number of defibrillatory shocks raised and became almost nihil after 9 shocks. Re-arrest could occur, so ROSC was no guarantee for survival.
Table 1. Univariate analysis for the performance of ALS where the activities, the i.v. drugs and the delay (categorized in discrete time intervals) are related to the survival for patients with shockable and nonshockable initial rhythms.

<table>
<thead>
<tr>
<th>ALS needed</th>
<th>Shockable rhythms (n = 578)</th>
<th>Nonshockable rhythms (n = 509)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Survival (%)</td>
<td>Alive / Total</td>
</tr>
<tr>
<td>No</td>
<td>86</td>
<td>65 / 76</td>
</tr>
<tr>
<td>Yes</td>
<td>11</td>
<td>56 / 502</td>
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<tr>
<td>Time to ALS</td>
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</tr>
<tr>
<td>0-4 minutes</td>
<td>53</td>
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</tr>
<tr>
<td>5-8 minutes</td>
<td>19</td>
<td>3 / 16</td>
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<td>9-12 minutes</td>
<td>16</td>
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<td>13-16 minutes</td>
<td>14</td>
<td>23 / 168</td>
</tr>
<tr>
<td>17-20 minutes</td>
<td>7</td>
<td>8 / 120</td>
</tr>
<tr>
<td>&gt;20 minutes</td>
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</tr>
<tr>
<td>ALS not performed</td>
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</tr>
<tr>
<td>ALS activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intubation - / Drugs -</td>
<td>0</td>
<td>0 / 21</td>
</tr>
<tr>
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<td>6</td>
<td>25 / 408</td>
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<tr>
<td>ALS i.v. drugs</td>
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<td></td>
</tr>
<tr>
<td>No drugs</td>
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<tr>
<td>Adrenaline</td>
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<td>1 / 126</td>
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<tr>
<td>Adrenaline/Lidocaine/Atropine</td>
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<td>5 / 64</td>
</tr>
<tr>
<td>Other drug regimes</td>
<td>23</td>
<td>18 / 79</td>
</tr>
</tbody>
</table>

* reference group, OR = odds ratio, CI = confidence interval, ALS = advanced life support.
3.3. Shockable initial rhythm: ALS procedure and outcome

From the 578 patients with a shockable initial rhythm, 76 (13%) patients did not require ALS measures in order to achieve ROSC (Table 1). Twenty-one percent (121/578) of patients with a shockable initial rhythm survived to hospital discharge. More than half (65/121) of the survivors did not need ALS interventions. From those who needed ALS, the longer the delay to the start of ALS the lower the survival. Delays over 20 minutes resulted in a minimal survival (2%), comparable to the situation when ALS was not performed. Patients in where no ALS activities were performed had the lowest survival chance and those who were only intubated besides defibrillation had the best change to survive. Furthermore when ALS was needed, any kind of drug regimes was related to a worse survival compared to no i.v. drugs administrated.

3.4. Nonshockable initial rhythm: ALS procedures and outcome

From the 509 patients with nonshockable rhythm, 7 did not need ALS efforts to achieve ROSC. When ALS was needed, delays of longer than 8 minutes resulted in a minimal survival rate. Concerning the ALS activities, those who were only intubated had the best change to survive. No i.v. drug was related to a better survival than any other drug regimes, although not all differences reached the level of statistical significance.

3.5. All initial rhythm: outcome and duration of ALS

From all 966 patients where ALS was performed, in 352 (36%) patients ALS efforts resulted in ROSC and 74 (8%) of these patients survived to hospital discharge. There was still a chance to achieve ROSC after 90 minutes of ALS (Figure 3). Survival was minimal after 25 minutes of ALS measures. One patient survived after 55 minutes of ALS procedures.

![Graph showing cumulative proportion of patients with ROSC and patients survived to discharge in relation to the duration of ALS in minutes.](image)

*Figure 3. The graphic presents the cumulative proportion of patients where spontaneous circulation was restored (ROSC) and of patients who survived to hospital discharge in relation to the duration of Advanced Life Support (ALS) in minutes. The chance to achieve ROSC is possible after even 90 minutes of ALS. When ALS measures took over 25 minutes, survival to hospital discharge diminished.*
4. Discussion

This observational study focussed on the last two links of the chain of survival: defibrillation and ALS. Survival decreased rapidly when time to defibrillation increased, especially when no BLS was performed. The vast majority of ROSC occurred after the first three defibrillatory shocks. Eighty-three patients did not need ALS procedures to restore spontaneous circulation, and these patients had the best chance to survive. When ALS was needed delay in the ALS procedures resulted in a decreased survival. Patients where no ALS was needed, but not was performed by EMS personnel had the worse chance of survival.

Shortening the delay to the first defibrillatory shock remains the most effective improvement of the emergency medical system for patients with a shockable initial rhythm as was described earlier. Also, performing BLS before arrival of EMS personnel positively affected survival for patients with a shockable initial rhythm. This study support the conclusions that BLS not only keeps the patient in VF, but also improves survival of patients found in VF when treated with a defibrillatory shock.

Although ALS is described as an essential link in the chain of survival, the additional benefit of ALS is questioned. The lack of any proven benefit of ALS activities is probably due to indication bias. The longer the duration of the resuscitation efforts, the more ALS interventions will be indicated and i.e. the more drugs will be administered. Our study demonstrated that in 83 cases ALS procedures not were even needed to restore circulation, as was also described earlier. For the other patients we found a beneficial effect of early performed ALS, regardless of the initially recorded rhythm. However, the amount of survivors with nonshockable rhythm was very small and no clear trend in time could be proven. We also found that ALS measures were indeed beneficial compared to patients where EMS personnel should, but could not perform ALS. It seems that after defibrillation, endotracheal intubation is the most important treatment of any circulatory arrest.

We found a high survival rate in the group of patients with a nonshockable initial rhythm that did not need ALS. The possible explanation for this finding is that there was probably no circulatory arrest, although EMS personnel did not detected a pulse. It is known from studies that even for professionals, conformation of a cardiac arrest by checking the carotid pulse could be difficult.

Bonnin et al. suggested in a previous study to terminate out-of-hospital resuscitation efforts after 25 minutes of ALS without recovery of ROSC, excluding hypothermic patients or persistent VF. In our study we found that survival was very little after 25 minutes, but still three patients left the hospital alive after ALS of longer duration.

Limitation of the study

Because we performed an observational study we could not control for the indication bias. Although we considered the different initial heart rhythms as the most important predictors for survival, many other differences could have biased our findings. For example, we did not take into account the experience of the ambulance crew, as was suggested by Soo et al.

Conclusion

We conclude that ALS is not always needed, resulting in the best chance to survive. When ALS is needed, benefit from ALS performance was most when administrated early. When analyzing the effect of ALS two findings must be taken into account: the need for ALS and the delay to ALS procedures. Prolonging ALS measures over 25 minutes seemed of limited value for out-of-hospital adult cardiac arrests. Early ALS remains a valuable link in the chain of survival.
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