Effects of Early Defibrillation by Ambulance Personnel on Short- and Long-term Outcome of Cardiac Arrest Survival*

The Munich Experiment

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Objectives: This study evaluates the feasibility of implementing early defibrillation of out-of-hospital cardiac arrest patients for basic life-support providers (EMT-D) in a two-tier emergency system in the city of Munich, Germany.

Design: Retrospective consecutive analysis of all EMT-D attempts during a 5-year initiation phase (1990 to 1994) and prospective follow-up of all cardiac arrest survivors discharged from hospital.

Setting: A strictly defined inner-city and suburban area of 978 km² and a residential population of 1,530,000 inhabitants with 22 ICUs in urban hospitals. One dispatching center to alert a two-tier emergency system with 56 EMT-D-staffed ambulances and physician-staffed mobile ICUs stationed at the nearest of nine hospitals.

Methods: All EMT-D cases were identified and data on patients were documented in a standardized manner from patients’ records, including the resuscitation protocol in the hospitals to which the patients were referred. For those patients discharged from the hospital, a standardized telephone interview was undertaken with the physician in charge of the patient and with the patient/relative leading to an assessment of the patient’s status according to the Glasgow-Pittsburgh cerebral performance categories.

Intervention: None.

Results: During the 5-year initiation phase of the EMT-D program in the two-tier emergency system in Munich, there were 243 resuscitation attempts by EMTs, using the semiautomated defibrillator; 125 patients died immediately on the scene. In 118 patients, spontaneous circulation was reestablished and these patients were admitted to an ICU in 1 of the 22 urban hospitals. Median call-response interval for the EMT-D was 5 min (interquartile range, 3 to 6) and was 10 min (interquartile range, 7 to 13) for the second tier (p<0.0001). In 34 cases (28.8%), EMT-D staff had reestablished spontaneous circulation (ROSC) before the second tier arrived on the scene. Patients with ROSC on the arrival of the second tier were more frequently discharged alive from hospital than patients without ROSC at that time (p<0.0001). The hospital discharge rate of initially successful resuscitated patients presenting with out-of-hospital ventricular fibrillation was 38.1% (45/118). Overall success rate of all EMT-D attempts was 18.5% (45/243). After a mean follow-up time of 39 (range, 22 to 64) months, 29 (66%) patients were still living. Twenty-five (56.8%) were neurologically not disabled or mildly disabled (CPC 1/2); disability was moderate in 3 (6.8%) patients and was severe in 1 (2.3%) patient. One case was lost to follow-up.

Conclusion: The present study demonstrates that the upgrading of basic life support providers with semiautomated defibrillators has a significant benefit for cardiac arrest victims outside the hospital in an urban environment.

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Key words: cardiopulmonary resuscitation; early defibrillation; out-of-hospital cardiac arrest

Abbreviations: AED=automated external defibrillator; CPC=cerebral performance category; EMT=emergency medical technician; EMT-D=emergency medical technician-defibrillation; EP=emergency physician; ROSC=spontaneous circulation; VF=ventricular fibrillation
Public health providers all over the industrialized world have established emergency medicine services, which are—despite many differences in structure and organization1—designed to provide first medical aid at any time and to intervene for immediate threats of life. Most emergency services in urban areas foresee a two-tier system, which has been proven to be most effective,2 mainly because a two-tier system allows advanced life support at the scene. Nevertheless, in a two-tier system, the more qualified medical teams, who are paramedics in North America and in some parts of Europe or emergency physicians in Germany, for example, may reach the patient with a considerable time delay after the first-aid ambulance teams, which are staffed with less-qualified emergency technicians. For cardiac arrest patients, such a delay may become a crucial issue as the prognosis of survival is extremely time-dependent.3-7 The key to improved cardiac arrest survival—especially for patients with ventricular fibrillation (VF) or pulseless tachycardia—is the rapid recognition and earliest possible correction of arrhythmias by cardioversion.8-10

Medical devices that allow automated detection and external defibrillation of malignant arrhythmias have been available since 1979.11 The technical feasibility of using these automated external defibrillators (AEDs) is proven.12-14 Thus, technological progress has made available advanced cardiac care outside the hospital by less-qualified personnel who generally arrive first at the scene. Therefore, the introduction of AEDs for use by personnel without the ability to diagnose heart rhythm abnormalities or to decide on countershock therapy has made the concept of defibrillation by emergency medical technicians (EMTs) more acceptable.14

Many reports have shown improved survival by the use of AEDs in the management of out-of-hospital cardiac arrest by EMTs.12-16 Nevertheless, controversy still surrounds the concept. This may be due to the fact that other studies have found less encouraging results.17-21 Furthermore, high equipment and personnel costs and reliance on medical technicians to render effective treatment in life-threatening circumstances have to be taken into consideration. Finally, concern remains that a major result of implementing more aggressive resuscitation efforts may create vegetative populations. The introduction of an EMT-defibrillation (EMT-D) program, therefore, has been accompanied by an evaluation process in various communities in North America and Europe such as Berlin,15 Brussels,16 Iowa,11 Seattle,10,14 Stockholm,20 Stockport, UK,19 or Memphis, Tenn.22

We report herein on the introduction of an EMT-D program in Munich, Germany. The first aim of the pilot study was to evaluate whether the implementation of an EMT-D system is feasible in the given structure of the Munich emergency service. A major process-oriented evaluation criterion of the study was whether the time window between start of resuscitation by EMT-D personnel and arrival of the emergency physician was wide enough to justify establishing an early defibrillation program. The second aim of the study was outcome oriented and was designed to determine whether survival of VF patients was improved by early defibrillation to a degree that other studies have reported. The reduction of mortality may lead to increased morbidity to an unfavorable extent. The third aim of the present study was to evaluate the long-term course of the successfully resuscitated cardiac arrest survivors and to investigate their quality of survival.

**Materials and Methods**

**Target Area**

The target area for this study was the city of Munich in southern Germany. Munich has an area of 978 km² and a residential population of 1,530,000 inhabitants. Of these, 48% are men. In 1993, the mean density of population was 4,044 inhabitants per square kilometer in the city and 416 inhabitants per square kilometer in the suburban area. The age distribution is shown in Figure 1. It shows that 14.7% of the inhabitants are older than 65 years. Of the population, 4.8% live below the poverty level, ie, require financial support from the community. In 1993, there were 15,088 deaths. There were 980 deaths per 100,000 individuals per year from all causes. Coronary artery disease was responsible for 17% of these deaths (ICD-9, 410 to 414).

**Organization of the Emergency Service**

In Munich, one central dispatching center is responsible for alerting an EMT-staffed ambulance on call located nearest to the operation area. These ambulances, manned by two or three EMTs, form the first tier. When the dispatcher suspects a life-threatening condition, he or she simultaneously alerts one of the physician-staffed mobile ICUs. These are stationed at nine hospitals and form the second tier with an emergency physician on board. In every case in which the first responder staff is faced with a life-threatening condition at the scene (which the dispatcher did not realize), the second tier will definitely be dispatched. There are 22 coronary care units available in urban hospitals spread throughout the city of Munich.

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EMT-D Program

The EMT-D program was initiated by a Munich consortium of public emergency system providers in 1990. The program includes a qualifying training course (including periodic activities for skill maintenance) for EMTs to use the AED during resuscitation, a standardized mission protocol with a defined defibrillation algorithm for the trained EMT who arrives first at the scene, and a mission documentation and evaluation of every case of resuscitation by two experienced emergency physicians who are independent of the providing organization. Semiautomatic defibrillators (LifePak 250/300TM; Physio Control; Redmond, Wash) were used by the EMT-D personnel. Data obtained by this device were the time of operation, the presenting arrhythmia leading to administration of the shock, number of shocks, and energy applied. Additionally, a voice recorder documented any spoken word on the scene. At the end of the initiation phase in 1994, 56 ambulances were staffed with semiautomated defibrillators. About 550 EMTs were qualified to participate in the program.

Study Design and Data Collecting

The present study was designed as a combined retrospective-prospective nonrandomized cohort study. Inclusion criteria for the study were all cardiac arrest patients successfully resuscitated by an EMT-D who operated semiautomatic defibrillators in the 5-year time period between January 1, 1990 and December 31, 1994 in the target area. Patients were considered to be eligible for the study when they were 20 years of age or older. Patients sustaining cardiac arrest due to a noncardiac cause (for example, traumatic etiology, intoxication/drug overdose, hypovolemia, or hypothermia) were excluded from the analysis.

The data sources for the retrospective analysis of all cases of cardiac arrest that were eligible according to the inclusion criteria were the patients’ records in 1 of the 22 referring hospitals with ICUs. These data were documented in a standardized manner; in a random sample of 20% of the cases, a quality control check of data collection was undertaken. Efforts were made to fulfill or to approximate the criteria of the Utstein style,21 information on the population served and approximations to the prevalence of confirmed cardiac arrests considered for resuscitation in the target area were obtained. Data were also collected on the presence of bystander cardiopulmonary resuscitation, the return of spontaneous circulation of patients, number of patients admitted to the hospital, and number of patients discharged alive. The time from the patient’s collapse to the initiation of the emergency call could not be documented accurately. The call-response intervals for the first- and second-tier staff were obtained from automated documentation in the dispatching center. Times were recorded to the nearest minute.

A standardized telephone interview with the physician in charge of the patient was undertaken to assess the general performance abilities at the study endpoint. An additional telephone interview with all patients who survived until July 1, 1996 was undertaken to assess the neuropsychological status of the patients. These data sources served to define the cerebral performance category according to the Glasgow-Pittsburgh cerebral performance scale.24 No patient refused to participate in the study. Data from all but one patient were obtained from the telephone interviews with the physician and the patients (or patients’ relatives).

Statistical Analysis

Call-response times (in minutes) for the first and second tiers are presented as medians (interquartile range) and differences between grouped data were analyzed by the t test for paired samples. Categoric variables were tested for equal distribution using the Pearson test (x^2). Differences were considered significant with a probability value of <0.05. We used stepwise logistic regression analysis as a multivariate model to identify the independent contribution of various factors to the prediction of in-hospital mortality after survival of a cardiac arrest. Statistical analysis was carried out on software (SPSS Inc; Chicago).

Results

Prehospital and Hospital Phase

During the 5-year initiation phase of the EMT-D program in Munich, there were 243 resuscitation attempts using the AED; 125 patients died immediately on the scene. In 118 (48.6%) patients, spontaneous circulation (ROSC) was reestablished and these patients were admitted to a coronary care unit in one of the 22 hospitals in the city. Of these 118 patients, 45 (38.1%) were discharged from the hospital alive. There were no patients with a cardiac arrest due to noncardiac origin (drug abuse; intoxication) among the survivors. These 45 patients account for a success rate of 18.5% of all EMT-D attempts. Of the 73 patients who died after successful admission to hospital, 21 (28.5%) died during the first 6 h of admission. A total of 28 (38.4%) patients died within 24 h of hospital admission.

Table 1 displays the median call-response intervals (the period from receipt of call by the emergency dispatcher to the moment when the emergency vehicle stopped moving) for the EMT-D staff and for the emergency physician (EP) vehicle. The median call-response interval for the EMT-D was 5 min and was 10 min for the EP (p=0.0001). This time difference opened a considerable time window for EMT-D operating as can be seen in Figure 2: for

![Figure 1](https://example.com/figure1.png)

**Figure 1.** Age distribution (18 to older than 85 years) of the mean population of Munich and the study population. CASA=cardiac arrest survival study population; München=mean population of Munich.
example, time saving of the EMT-D staff summed up to more than 11 min after 100 attempts performed.

In 50 (42.4%) cases, the second tier was not dispatched immediately because the dispatcher did not suspect a life-threatening condition or the condition of a patient became crucial after the EMT-D staff had already arrived at the scene. It is self-evident that the time difference would be high in these cases (Table 1). However, the median time difference was also pronounced even when first and second tier were alerted simultaneously (median, 8.5 min; interquartile range, 6.75 to 12.00 min). As can be seen in Figure 3, cardiac arrest survival was significantly (p≤0.06) related to early arrival of EMT-D, but was not related to arrival time of second-tier (EP) responders.

In 34 cases (28.8%), EMT-D staff had reestablished ROSC before the second tier arrived on the scene. Patients with ROSC by arrival of the second tier were more frequently discharged alive from hospital than were patients without ROSC at that time (p=0.0001). Additionally, other factors influenced survival after resuscitation (Table 2). In-hospital case fatality was higher in patients 60 years or older (p≤0.01) and in cases in which VF was not witnessed (p≤0.008).

All factors were entered in a multiple logistic regression model. A significant fit of the model was reached (p=0.001) when the following four factors were entered into the equation: age of 60 years or older, no ROSC before arrival of second tier, arrest not witnessed, and coma following cardiac arrest >1 h. The result of the regression analysis is displayed in Table 3: it shows that patients found without ROSC by arrival of the EP have a more than threefold risk of dying after arrival at the hospital than those in which ROSC was already reestablished by the EMT-D staff.

**Posthospital Phase**

Mean follow-up time after hospital discharge covered a period of 39 months (22 to 64 months) with a

![Figure 2](Image)

**Figure 2.** Cumulative time gain of arrival at scene of first-tier responder (EMT-D) to second-tier responder (EP) in 118 cardiac arrest survivors.

![Figure 3](Image)

**Figure 3.** Cardiac arrest survival, stratified in four time intervals of arrival at scene for first- (EMT-D) and second-tier (EP) responders in the study population (n=118). NS=not significant.

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**Table 1—Call Response Time for First (EMT-D) and Second Tier (EP) Emergency Providers (in Minutes), Also Stratified for Simultaneously and Delayed Alerted EP**

<table>
<thead>
<tr>
<th>Variable</th>
<th>No.</th>
<th>Median</th>
<th>50%</th>
<th>25%</th>
<th>75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMT-D</td>
<td>113</td>
<td>5.0</td>
<td>3.0</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>EP</td>
<td>118</td>
<td>10.0</td>
<td>7.0</td>
<td>13.0</td>
<td></td>
</tr>
<tr>
<td>EP alerted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simultaneously</td>
<td>66</td>
<td>8.5</td>
<td>6.75</td>
<td>12.0</td>
<td></td>
</tr>
<tr>
<td>Delayed</td>
<td>52</td>
<td>11.0</td>
<td>8.25</td>
<td>14.0</td>
<td></td>
</tr>
</tbody>
</table>

*EMT-D vs EP, p≤0.0001.

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**Table 2—Univariate Analysis of Factors Influencing In-Hospital Case Fatality of VF Survivors**

<table>
<thead>
<tr>
<th>Factor</th>
<th>No.</th>
<th>%</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt;60 yr</td>
<td>54</td>
<td>70.1</td>
<td>0.0113</td>
</tr>
<tr>
<td>Female sex</td>
<td>21</td>
<td>70.0</td>
<td>0.2281</td>
</tr>
<tr>
<td>Onset of event during daytime</td>
<td>42</td>
<td>58.3</td>
<td>0.1115</td>
</tr>
<tr>
<td>Not witnessed</td>
<td>14</td>
<td>93.3</td>
<td>0.0078</td>
</tr>
<tr>
<td>No bystander resuscitation</td>
<td>40</td>
<td>69.0</td>
<td>0.2523</td>
</tr>
<tr>
<td>Call response time &gt;8 min</td>
<td>5</td>
<td>55.6</td>
<td>0.7239</td>
</tr>
<tr>
<td>Shocks delivered &gt;4</td>
<td>34</td>
<td>75.6</td>
<td>0.1021</td>
</tr>
<tr>
<td>No ROSC before arrival of second tier</td>
<td>61</td>
<td>72.6</td>
<td>0.0001</td>
</tr>
<tr>
<td>Coma following cardiac arrest &gt;1 h</td>
<td>50</td>
<td>61.7</td>
<td>0.7173</td>
</tr>
</tbody>
</table>
median of 35 months. Forty-five patients (36 men and 9 women) were discharged alive from hospital after successful out-of-hospital resuscitation (one was lost to follow-up). The mean age of the patients was 61.1 years. In all cases but one, the Glasgow-Pittsburgh cerebral performance categories (CPC) were assessed. As can be seen in Figure 4, 15 patients (34% of patients discharged) had died (CPC 5) and 1 patient was in a vegetative state (CPC 4). This patient died 3 months after the end of the study. Three patients (7%) were in a state of severe cerebral disability (CPC 3). Four patients (9%) showed symptoms of moderate cerebral disability (CPC 2) and the remaining 21 (47%) patients exhibited good cerebral performance (CPC 1). One case was lost to follow-up.

Among factors assessed to predict long-term mortality (Table 4), older age was the most significant factor (p≤0.0008). Unwitnessed arrest was also significant (p≤0.01). Resuscitation without assistance by bystanders was not a significant risk factor for in-hospital mortality, but was for long-term mortality (p≤0.02).

**DISCUSSION**

**Time Window for Early Defibrillation**

The time to initiation of resuscitation is the most important factor affecting survival from out-of-hospital cardiac arrest. A relative valid approximation to this time interval is the mean call-to-response interval. The present study proves that EMT-D significantly reduced the time interval between collapse and defibrillation by the difference in time between the arrival of the first and second tier. Defibrillation would not have been applicable otherwise in this crucial time period.

This finding is not obvious, because, as Kellermann et al have demonstrated, to achieve a feasible time window for first-responder defibrillation in communities already served by fast-response advanced life support staffs may be much more difficult. Richless et al also found that simply introducing an EMT-D program into an emergency medical services system that is not prepared to respond quickly to the scene of cardiac arrest patients will not necessarily improve cardiac arrest survival. The effects may be also less impressive in comparison to a single-tier system, in which the first countershock is not administered before the patient arrives at the hospital. Time savings in such a system have face validity when the provider of basic life support is equipped with an AED. In a meta-analysis of US EMT-D trials, Auble et al confirmed that the mean reduction in the mortality in single-tier systems for EMT-D was 13.6%, whereas it was only 6.3% in two-tier trials.

Despite an effective second-tier system, time savings in the present study summed up to more than 11 min for 100 EMT-D operations, which appears to be a significant potential for survival and quality of survival. Weaver et al estimated from their data that the survival rate in witnessed cardiac arrest cases decreased by 4% for each minute during the period after the initiation of basic life support until the delivery of the first shock. Herlitz et al proved that the reduction of the interval between collapse and first defibrillation from 9 to 10 min to 5 to 6 min doubled the chance of patients being discharged alive.

**Hospital Mortality**

The hospital mortality rate in the present study was 62%. In previous studies that addressed specif-
ically in-hospital case fatality for cardiac arrest survivors in similar populations, hospital mortality has been reported to vary between 32% and 54%.25-27 Dickey and Adgey26 studied 281 patients, aged 14 to 82 years (mean, 58 years), successfully resuscitated from VF outside the hospital in Belfast, and found 91 (32%) patients who died in hospital. Herlitz et al25 analyzed 448 VF survivors in Göteborg, of whom 262 (58%) patients died during initial hospitalization. To our knowledge, case fatality immediately after hospital admission has not been reported in these studies. Grupp et al27 reported on 246 patients with a cardiac arrest of cardiac origin outside the hospital in Edinburgh. Of those, 126 died in hospital (51%). There were 215 (88%) patients with VF. However, in-hospital mortality of VF survivors was not reported separately.

The case fatality rate of 62% in the present study significantly exceeds those figures. However, 21 patients in the present study died immediately after arrival to the hospital and had no further potential to survive and, in most cases, no further cardiac care unit specific resuscitation efforts were undertaken. When excluding these patients from the group of in-hospital mortality cases, the mortality rate in the hospital decreases to 53.6% (52/97), which is in the range of the figures reported by the studies discussed.25-27

Several factors affect in-hospital case fatality from out-of-hospital cardiac arrest: factors related to the pre-morbid state of the cardiac arrest victim as well as factors related to the resuscitation attempt itself. In-hospital case fatality was higher in patients older than 60 years, which is in agreement with data reported previously.25,26,28,29 There are other studies that found that age itself was not a major determinant of outcome.27,30 Female gender was a significant univariate risk factor in the study of Herlitz et al25 and was higher, although not significantly, in the present study and in the study of Grupp et al.27

Among factors related to the resuscitation attempt itself, unwitnessed arrest was a strong predictor of case fatality in the present study, presumably because unwitnessed arrest is a parameter of a prolonged delay time.27,31 The requirement of four or more shocks to correct VF has been shown to be a predictor of in-hospital mortality.26 The present study confirmed this result, although the difference did not reach significance. Additionally, early initiation of (advanced) basic life support of EMT-Ds in the present study was predictive for survival; whereas in these particular cases, arrival time of the second tier had no influence on outcome. These results support findings showing that the initiation of cardiopulmonary resuscitation is most time sensitive, while subsequent advanced life support procedures may be less time dependent.32,33

In 30% of cases, VF was already converted into a sinus rhythm and ROSC had returned when the EP arrived on the scene. The size of this patient stratum is similar to that of Weaver et al34 who reported that about 25% of the patients with VF in their study who were treated by EMT-D had regained pulse and BP before paramedics arrived. These patients had a significantly better survival rate than those without ROSC (p<0.0001). In the logistic regression model, this factor was the most sensitive one to predict in-hospital mortality.

These findings give further evidence for the efficiency of the EMT-D system. Nevertheless, additional advanced life support on the scene is a factor that also contributes to favorable outcome. Jakobsson et al20 reported on their evaluation of 1 year's experiment of early defibrillation in Stockholm, which has some similarities to Munich in the size of the city. Two hundred six patients received counter-shocks by AEDs. Twenty-eight of these patients regained circulation and were admitted for further hospital care. Not more than three patients (1.4%) survived to be discharged from the hospital. This unfavorable result may be due to the fact that additional advanced life support was not provided on the scene.

**Discharge Rates**

The hospital discharge rate of initially successfully resuscitated patients presenting with out-of-hospital VF was 18.5% in the present study. Other studies have documented VF survival rates, when EMT-D programs were instituted, of 13% by Jaggarao et al35 in 1982, of 19% by Stults et al11 in 1984, of 30% by Eisenberg et al12 and of 14% by Weaver et al26 both in 1984, of 13% by Stults et al27 and of 27% by Weaver13 both in 1986, of 28% by Cummins et al14 in 1987, of 30% by Weaver et al34 in 1988, of 18% by Arntz et al15 in 1993, of 19% by Mols et al16 and of 25% by Schneider et al17 both in 1994, and of 14.9% by Guly et al33 in 1995. There were also studies to show no or only minor effects like a survival rate of 9% by Richless et al21 in 1993 or 8% by Heber18 in 1983; but also even of <1% by Gray et al19 in 1987 and of 1.4% by Jakobsson et al20 in 1989. Thus, the discharge rate in the present study was successful in comparison to rates reported in the literature.

**Follow-up Status**

After a mean follow-up time of 39 months, 29 (66%) patients were still living in the present study. This is similar to a recent investigation by Cobbe et al31 who followed up 680 discharged cardiac arrest
survivors and assessed a 68% product limit estimate of 4-year survival after discharge. In 1982, Eisenberg et al. found an approximate 4-year-survival rate of discharged cardiac arrest patients of 49%. The 5-year survival rate was 61% in Rotterdam and was 45% in Göteborg. However, in the Göteborg study group of Herlitz et al., there were also patients with asystole as initial arrhythmia.

Survival in the present study is equal or superior in comparison to these data. This may be due in part to the resuscitation technique applied. However, it is generally believed that long-term mortality after cardiac arrest is more dependent on underlying causes and the treatment of malignant arrhythmias than of resuscitation parameters. Progress in prevention of sudden cardiac death in high-risk patients will further improve these figures.

Besides survival to hospital discharge, the quality of survival is an outcome measurement of similar importance. Reduction of case fatality in VF patients has not led to increased morbidity: neuropsychological status in 57% of patients was normal or mildly disabled. Disability was moderate in 7% of survivors and 2% were severely disabled. Early findings of Liberthson et al. have shown that 60% of cardiac arrest survivors who were discharged from short-term hospital care returned to prearrest status; 28% had mild and 12% had severe neurologic deficits. These figures appear to have remained stable over time.

CONCLUSIONS

These data provide evidence that for a two-tier emergency system in a predominantly urban area like in Munich, the introduction of early defibrillation for basic life support providers is feasible and has a significant benefit for cardiac arrest patients. The upgrading of basic life support providers with defibrillation devices saves lives and enhances the quality of survival. Thus, the study ascertains the contribution of automatic defibrillators to the overall management of cardiac arrest in an urban environment with an established emergency medical system.

Limitations of the Study

The present study does not provide a control group of survival rates of second-tier resuscitated cardiac arrest survivors. The study is therefore restricted to the analysis of the feasibility of implementing EMT-D in a two-tier system. The design of the study does not allow a comparison of different treatment and operating procedures. It proves, however, that EMT-D opens a significant time interval to deliver electrical conversion to VF patients outside the hospital and has a beneficial effect on survival.

The missing of an external control group may be less limiting for a feasibility study than the assessment of a baseline of prevalence of VF cases and survival rates before introduction of the EMT-D system. Therefore, it is not possible to confirm directly by study data whether early defibrillation has increased the overall rate of attempts and of VF survival in the target area. The study can also be biased by the potentially confounding effects of motivation and observation that typically accompany the introduction of any technology. It cannot be completely excluded that a restricted number of EMT-D attempts were unlogged or unreported.

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