In-hospital Cardiopulmonary Resuscitation
Prearrest Morbidity and Outcome

Rien de Vos, RN, PhD; Rudolph W. Koster, MD, PhD; Rob J. de Haan, MS, PhD; Hans Oosting, PhD; Poll A. van der Wouw, MD; Angela J. Lampe-Schoenmaeckers, MD

**Background:** Considerations about the application of cardiopulmonary resuscitation (CPR) should include the expected probability of survival. The survival probability after CPR may be more accurately estimated by the occurrence in time of the prearrest morbidity of patients.

**Objective:** To identify risk factors for poor survival after CPR in relation to the dynamics of prearrest morbidity.

**Methods:** Medical records of CPR patients were reviewed. Prearrest morbidity was established by categorizing the medical diagnoses according to 3 functional time frames: before hospital admission, on hospital admission, and during hospital admission. Indicators of poor survival after CPR were identified through a logistic regression model.

**Results:** Included in the study were 553 CPR patients with a median age of 68 years (age range, 18-98 years); 21.7% survived to hospital discharge. Independent indicators of poor outcome were an age of 70 years or older (odds ratio [OR] = 0.6, 95% confidence interval [CI] = 0.4-0.9), stroke (OR = 0.3, 95% CI = 0.1-0.7) or renal failure (OR = 0.3, 95% CI = 0.1-0.8) before hospital admission, and congestive heart failure during hospital admission (OR = 0.4, 95% CI = 0.2-0.9). Indicators of good survival were angina pectoris before hospital admission (OR = 2.1, 95% CI = 1.3-3.3) or ventricular dysrhythmia as the diagnosis on hospital admission (OR = 11.0, 95% CI = 4.1-33.7). Based on a logistic regression model, 17.4% of our CPR patients (n = 96) were identified as having a high risk for a poor outcome (<10% survival).

**Conclusions:** Time of prearrest morbidity has a prognostic value for survival after CPR. Patients at risk for poor survival can be identified on or during hospital admission, but the reliability and validity of the model needs further research. Although decisions will not be made by the model, its information can be useful for physicians in discussions about patient prognoses and to make decisions about CPR with more confidence.

Arch Intern Med. 1999;159:845-850

---

**From the Resuscitation Committee (Drs de Vos and Koster) and the Departments of Cardiology (Drs Koster and van der Wouw), Clinical Epidemiology and Biostatistics (Drs de Haan and Oosting), and Anesthesiology (Dr Lampe-Schoenmaeckers), Academic Medical Center, University of Amsterdam, Amsterdam, the Netherlands.**

**Physicians have** no responsibility to provide futile or unreasonable care; thus, cardiopulmonary resuscitation (CPR) should be applied only if considered effective, useful, and not harmful. By excluding patients with expected poor survival, resources also can be saved, although resuscitation should not be withheld just for financial reasons.

With the exception of zero survival, there is no consensus about what futile care implies. In the case of zero survival, a physician can withhold resuscitation even when a patient or family insists. If the survival probability is not zero, discussions with patients are needed about the trade-off between the survival probability and the quality of life after CPR. Patient preference for CPR is affected by information about survival probability. However, is it possible to give patients an accurate estimate of this probability? It is suggested, for example, that some physicians can make no better predictions than can be expected by chance alone.

Formal decision rules could support decisions about CPR, but for ethical and statistical reasons physicians and patients remain the decision makers, and rules are not decisive. Unfortunately, current decision aids have failed to predict survival. In agreement with the literature, these decision aids consider the age of the patient, the level of self-care, and the presence or absence of morbidity before CPR. The fact that morbidities occur over time is not considered. This time can be divided in 3 functional time frames: morbidity before hospital admission, morbidity as the reason for hospital admission, and morbidity emerging during hospital admission. The distinction is clinically relevant because ideally, a do not resus-
PATIENTS AND METHODS

We studied cardiac arrests in the Academic Medical Center, University of Amsterdam, Amsterdam, the Netherlands (a tertiary care hospital with 1000 beds and 26 000 admissions annually), between June 1988 and December 1994. The 24-hour resuscitation team consisted of an anesthesiology resident, a cardiology resident, and an anesthesiology nurse. The team provided advanced life support to patients on all nursing wards and in the emergency department according to a protocol based on the guidelines of the American Heart Association and the European Resuscitation Council. Basic life support was initiated by ward nurses. The hospital policy is to always initiate CPR in the case of cardiac arrest unless a DNR-order is present.

Cardiopulmonary resuscitation was defined as the application of artificial ventilation and external chest compressions after confirmed loss of palpable pulse or immediate defibrillation after confirmed ventricular fibrillation.

The study cohort consisted of all consecutive patients aged 18 years and older with an in-hospital cardiac arrest and an attempted resuscitation by the resuscitation team. We excluded patients with (1) an out-of-hospital cardiac arrest and (2) a second and subsequent cardiac arrest during the same hospital admission. The study protocol was approved by the medical ethics committee of the Academic Medical Center.

Calls for the resuscitation team were identified through automatically recorded tapes at the central hospital switchboard. After each call, the resuscitation team completed a detailed standard form. Medical records of CPR patients were evaluated by 2 reviewers. Patient characteristics included age and sex, functional status before hospital admission, and relevant medical diagnoses. Disorders were defined as relevant if the medical records showed them as a significant problem without setting strict quantitative criteria for severity of illness. The medical diagnoses were coded and clustered according to the International Classification of Diseases, Ninth Revision.19 Cardiac disorders were defined as codes 391 to 429; pulmonary embolism (code 415) was excluded. All other codes, 415 included, were classified as “noncardiac.”

TIME FRAMES

Before hospital admission, patients can have 1 or more morbidities, and the main indication for admission will be determined by 1 of these. During hospital admission, new morbidities may develop. Accordingly, we categorized the medical diagnoses into 3 functional time frames: morbidity before hospital admission, main morbidity on hospital admission, and new morbidity during hospital admission. Morbidities before hospital admission included all active disorders that required treatment (eg, cancer) and inactive disorders with expected late effects present in the year before hospital admission (eg, myocardial infarction). As the main morbidity on hospital admission we selected 1 morbidity as the primary admission diagnosis. New morbidities during hospital admission were defined as disorders emerging from the day of hospital admission to 24 hours before the cardiopulmonary arrest. Morbidities developing within 24 hours of the arrest were expected to be too acute to affect a DNR-order.

All morbidities were analyzed, but they were presented only if their prevalence was 1% or greater or if results of previous studies indicated a relationship with the outcome after CPR; outcome was survival at hospital discharge or death.

STATISTICAL ANALYSIS

Differences in survival associated with morbidities before, on, and during hospital admission were analyzed with the χ² statistic and expressed as relative risks (RRs) with 95% confidence intervals (CIs). In multivariate analysis, all morbidities associated with the outcome after CPR with a P<.20 at the univariate level and age, sex, and functional status before hospital admission were entered into a logistic regression model. We used the outcome on discharge (death or survival) as a dependent variable (SPSS v6.1.1, SPSS Inc, Chicago, Ill). Significant independent explanatory factors were identified by backward elimination. The effect sizes were expressed as odds ratios (ORs) with 95% CIs. Interaction was investigated between the main factors and a biological plausible subset of comorbidities. Calibration of the model was assessed with the Hosmer-Lemeshow goodness-of-fit test.25 This test compares observed and expected frequencies of the outcome in groups based on the values of the estimated probabilities using the logistic model. In addition, we plotted a calibration curve comparing the observed percentages of survival grouped by the estimated percentages of the logistic model. Results were statistically significant at P<.05.

The resuscitation team received 1398 emergency calls, which included true cardiopulmonary arrests (n=850), respiratory arrests only (n=182), and medical emergencies for which CPR was not required (n=366). From the 850 patients with cardiopulmonary arrests, we excluded from analysis patients declared dead on arrival of the resuscitation team (n=11), those younger than 18 years (n=63), patients with out-of-hospital cardiopulmonary arrest ongoing into the emergency department (n=170), and second or later arrest in the same patient (n=48). The medical records of 5 patients could not be traced. A total of 553 CPR patients entered the study, 317 men and 236 women with a median age of 68 years (range, 18-98 years). At hospital discharge 120 patients (21.7%) were still alive. No association was found between sex and survival. Patients aged 70 years and younger (n=266) were more likely to survive than were older patients (23% vs 18%, RR=1.4, 95% CI=1.0-2.0). Patients who were functionally independent before hospital admission (n=494)
were nearly twice as likely to survive as those who were functionally dependent (23% vs 12%, RR = 1.9, 95% CI = 0.9-3.9).

MORBIDITIES BEFORE HOSPITAL ADMISSION

There was no difference in survival associated with the presence or absence of morbidity before hospital admission (22% vs 22%). When morbidities were present before hospital admission, significant differences in survival existed between the morbidities. Survival was significantly higher in patients with only a cardiac morbidity than in those with only noncardiac or combined cardiac and noncardiac morbidities (30% vs 17%, RR = 1.8, 95% CI = 1.3-2.4). Angina pectoris was associated with relatively high survival (30%) (Figure 1).

No survival was found in noncardiac morbidities such as acquired immunodeficiency syndrome, gastrointestinal tract bleeding, pneumonia, psychiatric disorders, and sepsis. Relatively low survival (≤10%) was found in cases of cirrhosis (10%), renal failure (9%), stroke (9%), and transient ischemic attacks (8%). Morbidities with poor survival showed low prevalence and consequently wide 95% CIs (eg, sepsis). This was not the case in patients with renal failure or stroke.

Figure 1. Morbidity before hospital admission in relation to survival after cardiopulmonary resuscitation. Morbidity before hospital admission included all active disorders requiring treatment and inactive disorders with expected late effects. Differences in survival associated with morbidities before hospital admission were expressed as relative risks with 95% confidence intervals. In most morbidities with poor survival, the prevalence was low and consequently the confidence intervals were wide, with renal failure and stroke as exceptions. Angina pectoris, renal failure, and stroke were entered into a logistic regression model (P = .20). Prevalence percentages do not add up to 100% because multiple morbidities could occur in a single patient.

Figure 2. Main morbidity on hospital admission in relation to survival after cardiopulmonary resuscitation. As the main morbidity on hospital admission, we selected 1 preexisting morbidity as the reason for hospital admission (primary admission diagnosis). Differences in survival associated with morbidities before hospital admission were expressed as relative risks with 95% confidence intervals. Relatively high survival was specifically observed in cases of angina pectoris and ventricular dysrhythmia, 37% and 70%, respectively. Angina pectoris, ventricular dysrhythmia, aorta aneurysm, and pneumonia were entered into a logistic regression model (P = .20).

A few morbidities that were the indication for hospital admission were significantly associated with survival after resuscitation. Survival with a cardiac morbidity on hospital admission was significantly higher than survival with a noncardiac morbidity (29% vs 15%, RR = 2.0, 95% CI = 1.4-2.7). Relatively high survival was observed in cases of angina pectoris (37%) and ventricular dysrhythmia (70%) (Figure 2).

Relatively low survival was found in noncardiac morbidities, such as aortic aneurysm (6%). No survival was observed in acquired immunodeficiency syndrome, chronic obstructive pulmonary disease, gastrointestinal tract bleeding, liver or pancreas disorders, pneumonia, or psychiatric disorders.

NEW MORBIDITIES DURING HOSPITAL ADMISSION

During hospital admission, 47% of the patients developed a new morbidity. Survival was significantly higher without than with a new morbidity (30% vs 13%, RR = 2.4, 95% CI = 1.6-3.4). Survival between new cardiac morbidity vs new noncardiac morbidity was not significantly different (18% vs 22%, RR = 0.81, 95% CI = 0.5-1.3). Congestive heart failure occurred relatively frequently during hospital admission and was signifi-
When all univariately identified (co)morbidities (P<=.20) and patient characteristics (sex, age, and functional status before hospital admission) were entered into a multivariate logistic regression model, 6 factors were independently associated with survival (Table). An age of 70 years and older, stroke or renal failure before hospital admission, and congestive heart failure during hospital admission were independently associated with low survival, whereas angina pectoris before hospital admission or ventricular dysrhythmia as the main hospital admission diagnosis were associated with high survival.

We could not demonstrate significant interactions between the different factors. The Hosmer-Lemeshow goodness-of-fit statistic was not significant (P = .70), which indicates a well-calibrated model.

The calibration curve compared the distribution of the observed probability of survival with the estimated probability as defined by the logistic model. The curve shows that survival was 30% or less in most patients (87%) (Figure 4). In this group, we found close concordance between the observed and the estimated probability of survival. With a survival of more than 30%, which concerned 13% of the patients, the estimated outcome became less certain. Ninety-six patients (17.4%) were in the subgroup with an estimated probability of survival of 10% or less. In this low-probability group, 6 patients (6%) survived to discharge from hospital.

Together with other considerations, decisions about whether to attempt resuscitation also concern the probability of survival, but predictions of survival are difficult to make. To support the decisions, we studied pre-arrest morbidity related to the time of occurrence to provide more detailed information.

The general survival in our patient group was 21.7%. Risk factors for poor survival were patient age, stroke or renal failure before hospital admission (OR = 0.6, 0.3, 0.3), and congestive heart failure during hospital admission (OR = 0.4). Indicators of relatively good survival were angina pectoris before hospital admission or ventricular dysrhythmia as the reason for hospital admission (OR = 2.1, 11.0). These factors had no detectable effect on the outcome when occurring in the other time frames. In general, patients without new morbidities during hospital admission fared better than those with new morbidities (RR = 2.4). In general and for specific diseases, it can thus be relevant to make a distinction in the time of occurrence of morbidities.
Based on this distinction, 17.4% (96/553) of our patients could be identified as a high-risk group for a poor outcome (<10%) before resuscitation. Six of these patients (6%) survived. There is no consensus about the remotest probability of survival when resuscitation is no longer worthwhile to undertake, except the probability of zero.3 There are no scientific studies on the subject that can give this certainty.3 The results of our study show also that some patients can survive against all odds. This does not mean that our information is worthless for clinical purposes. Probabilities offer useful information for physicians in discussions about the prognosis of patients and also to elicit patient preferences for resuscitation.2 However, solely using probabilities as binary predictors for making treatment decisions for individual patients can be misleading, even when the model performance overall is good.25 Although remote, there will always be a chance that patients survive. Furthermore, it should be realized that models are useful for the description of groups of patients but that their performance may vary considerably for individual patients. Consequently, decisions based purely on models must be approached with caution.

Our study concentrated on adult patients with specific diagnoses, a population that can generally be found in hospitals. For this reason, patients with a cardiac arrest before hospital admission were excluded because they are a different target group and their determinants of survival are not primarily related to prearrest morbidity. We also excluded patients with multiple cardiac arrests. Their clinical history is complex (multiple intensive care unit admissions, mechanical ventilation, and coma), and the outcome depends on this history. This is an important group of patients, but different from the others, and should receive separate attention. The patient scenarios that also cannot be found in our study are, for example, trauma patients or children. If other studies also give no information about the probability of survival of these patients, resuscitation is to be recommended if a cardiac arrest occurs.

We did not consider acute morbidities that occur within 24 hours of cardiac arrest. In our hospital, decisions not to attempt resuscitation are made after ample deliberation by senior physicians who are only present during the day. Furthermore, it is our clinical experience that in acute situations, such as severe hemorrhage, one does not withhold resuscitation but attempts to save the life of the patient even when the chances of success are known to be remote. If the patient survives such an event, resuscitation in case of recurrence of the hemorrhage is discussed. Therefore, it is reasonable to consider these acute events to be of little or no effect on resuscitation decisions.

We did not set specific criteria for the severity of illness. It is beyond doubt that this is a highly clinically relevant issue and can add further precision to our estimates, but there are no well-accepted severity classifications for every disease. When studying medical records, it is also difficult to categorize patients in such classifications, if they exist. Furthermore, such an exercise would have led to many subgroups of patients and would have diminished the statistical power to detect relevant differences in outcome. It remains unclear how other authors have dealt with the aspect of severity of illness; we restricted ourselves to those that were clinically significant, and we did not analyze apparent trivial events. Apart from this, some discriminative power also may have been lost by distinguishing time frames. That is, the identified risk factors were highly prevalent, and low-prevalence potential risk factors may have remained undetected because of their low prevalence in some time frames, eg, sepsis. This may specifically be the case for morbidities that occurred during hospital admission.

Our idea to study prearrest morbidity is not unique, but differentiation of prearrest morbidities in relation to time frames is, to our knowledge, a new approach. Others used for prediction of the outcome information about clinical events during or after CPR21-24 or focused on its immediate success.25 By design, models that use information during or after CPR have little meaning for decisions about resuscitation that take place before cardiac arrest. George et al26 proposed a prearrest morbidity index to predict the outcome; they measured the prearrest morbidity rather statically as the presence or absence of morbidity. Results of a recent study by Ebell et al27 show that different models, based on static evaluation of prearrest morbidity, did not predict survival after resuscitation. So far, our model explains the outcome after resuscitation but, to be accepted as a supportive model, more research is needed in terms of reliability, discriminative ability, and internal and external validity.20

Some risk factors in our study are known, but stroke and congestive heart failure were previously considered weak predictors.18 This may illustrate the effect of whether a distinction is made between time frames. In our study, for example, congestive heart failure was not a risk factor as preadmission morbidity or morbidity on hospital admission, whereas it was a potent risk factor when emerging during hospital admission. It is likely that if we had considered the total occurrence of congestive heart failure during the 3 time frames, the prognostic value of heart

Figure 4. Calibration curve comparing the distribution of patients in relation to observed and estimated probability using logistic regression. Vertical bars represent the percentage of patients undergoing cardiopulmonary resuscitation in each decile of estimated probability; dots, the observed probabilities of survival in each decile of the estimated probabilities by the model; and line of identity (x = y), perfect prediction: observed outcome equals estimated probability.
failure during hospital admission would have been “diluted” and consequently we would have reported similar results as previous authors.

Cardiomyopathy before and on hospital admission was associated with a nearly 2-fold higher survival than was noncardiac morbidity (RR = 1.80 and 1.95, respectively). During hospital admission, survival in the case of cardiomyopathy equaled that of noncardiac morbidity. The “advantage,” in terms of survival, of having a cardiomyopathy thus depends on the time frame. This may be caused by a lower incidence of ischemic cardiac diseases during hospital admission than in the other time frames or with a relatively acute onset in this phase. There are many competing arguments why patients with cardiomyopathies fare better after resuscitation than those with noncardiac morbidities, such as the difference of initial heart rhythm at cardiac arrest, monitoring before cardiac arrest, or severity of illness. It would be interesting to investigate these arguments in subgroups of patients.

In this study, we demonstrated that cardiac arrest occurs in a heterogeneous group of hospitalized patients and that we can make inferences about the survival of high-prevalence morbidities in different time frames. Ideally, a DNR-order should be discussed with every patient on hospital admission and adjusted after clinically relevant changes in his or her health. Our model is not a decision rule that replaces such a discussion. When deciding on a DNR-order, decision makers may not be comfortable with prognostic information, particularly when the chance of survival is small but not zero. For a balanced decision, additional aspects such as quality of life and patient preferences must also be considered.25–27 Nevertheless, the decisions will be made with more confidence if the information about survival after resuscitation is improved. Our model based on time frame–dependent morbidities may give such supportive clinical information.

Accepted for publication August 6, 1998.

This work was supported by a grant from the Netherlands Heart Foundation, The Hague, the Netherlands.

Reprints: Rien de Vos, RN, Academic Medical Center, University of Amsterdam, Division Operatino Center, Meibergdreef 9, PO Box 22700, 1100 DE Amsterdam, the Netherlands (e-mail: r.vos@amc.uva.nl).

REFERENCES

1. Luce J. Physicians do not have a responsibility to provide futile or unreasonable care if a patient or family insist. Crit Care Med. 1995;23:760-766.


