ORIGINAL ARTICLE

Resuscitation Predictor Scoring Scale for in-hospital cardiac arrests

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Objectives: The purpose of this study was to determine the key factors influencing survival from cardiopulmonary resuscitation attempts and to produce a survival predictor scale for use during a resuscitation attempt.

Method: Bivariate analysis of individual survival predictors and a prospective analysis of survival based on logistic regression models. Included in this seven year study (1993-2000) were 2567 in-hospital resuscitation calls of which 1633 received full cardiopulmonary resuscitation. Immediate, 24 hour and discharge survival rates were the main outcome measures with additional analysis for the development of the Resuscitation Predictor Scoring Scale (RPS Scale).

Results: The immediate survival rate was 41%, 28% at 24 hours, and 19% by discharge. Multivariate analysis showed the main factors influencing 24 hour survival to be the duration of the arrest, primary arrhythmia (VT, VF, asystole, or PEA), age, and the primary mode of arrest (respiratory or cardiac). The RPS Scale was developed from these key predictors giving resuscitation teams an accurate prediction of survival 15 minutes into a resuscitation attempt.

Conclusion: Data collection and analysis of cardiopulmonary resuscitation attempts are essential for the formulation of survival indicators. In this case the data have enabled the formulation of a survival predictor scale that will quantify the decision making process regarding the termination of cardiopulmonary resuscitation attempts.

A number of pre-arrest morbidity scales¹⁻³ have been developed over the years to aid in "do not attempt resuscitation" (DNAR) decisions. They are all designed for use with a specific "cut off" value above which patients will not survive. However, they tend to be less sensitive when it comes to predicting who will survive below the "cut off" point. This is because there are so many other factors, other than pre-arrest morbidity, that influence survival.⁴ Nevertheless they remain useful guides for DNAR decisions.

To date there is no specific tool available to aid decision makers during a resuscitation, decisions that are inevitably complex and subjective. Rien de Vos *et al*⁵ for example concluded that "the point in time to terminate resuscitation is not always rationally chosen" and Meyer and Balck⁵ suggest that physicians may have some conflict with their decision making.

The criteria for terminating resuscitation efforts are clearly multifactorial and consequently there is no clear guidance. A recent publication of international guidelines⁶ makes the point that "in the absence of mitigating factors, prolonged resuscitation efforts for adults and children are unlikely to be successful and can be discontinued if there is no return of spontaneous circulation at any time during 30 minutes of cumulative ACLS". However, a later paper within the same publication⁷ that considers the termination of out of hospital resuscitation efforts in the asystolic patient, suggests that where basic and advanced interventions have been in place for 10 minutes resuscitation should be discontinued.

With these issues in mind we report on a retrospective analysis of resuscitation survival rates and key predictors of survival. We have also produced a survival predictor scale (to 24 hours) that can be used during an in-hospital resuscitation attempt to aid termination decisions.

METHODS

Derriford Hospital, Plymouth (UK) is a 1200 bed district general hospital. The resuscitation team is led by a medical senior

house officer (SHO) with the support of a medical house officer (HO), an intensive care SHO, and an intensive care nurse.

The study ran from April 1993 to March 2000 in which time there were 2567 reported resuscitation calls. Data were stored on a Microsoft Access data base and transferred to the Statistics Package for Social Scientists (SPSS) for analysis. As recommended in the Utstein style,⁸ excluded from the main body of this study were 354 calls (16%) where the team was not required, such as a false alarm or where the patient was found to be "not for resuscitation"; 69 calls (3%) to patients in respiratory arrest only; 39 calls (2%) to patients less than 20 years of age; and 472 calls (19%) to 204 patients who arrested more than once during a hospital admission. The remaining 1633 patients received full cardiopulmonary resuscitation (CPR), for a single event.

Immediate CPR success was defined as the return of spontaneous cardiac output for a minimum of 20 minutes. Survival at 24 hours and survival at discharge from hospital, or six weeks, were also calculated. Data collection was coordinated by the resuscitation department with the intensive care doctor responsible for completing an audit form after each call. In some areas, for example, coronary care and accident and emergency, staff were capable of managing a resuscitation attempt without the assistance of the general resuscitation team. In these areas data collection proved more difficult and we estimate that the real number of resuscitation attempts was about 15% higher. With this in mind the following data may be slightly less representative of acute care areas than for general wards.

Abbreviations: DNAR, do not attempt resuscitation; CPR, cardiopulmonary resuscitation; RPS Scale, Resuscitation Predictor Scoring Scale

Table 1 Survival rates related to primary arrhythmia (combined rhythms)

Primary arrhythmia	Number of cases	Survival rates %		
		Immediate	24 Hour	Discharge
VT and VF	433	53	46	36
Asystole and EMD/PEA	962	27	14	6
Total	1395			

Statistical analysis

The SPSS was used for statistical analysis. Bivariate analysis of nominal data was performed using χ^2 analysis with Yates's correction, interval and nominal with the independent samples *t* test, and interval data with Pearson's (*r*) product moment. Significance was accepted at the 0.05 level. Non-directional hypotheses (two tailed) are reported.

Multivariate analysis using multiple forward logistic regression was performed on factors that reached significance (<0.05) in bivariate analysis. The RPS Scale was developed from the final logistic regression model that gives a weighting as an odds ratio score (the exponential β) for each variable. These scores (rounded to whole numbers) were then allocated to all patients in the dataset. This enabled us to calculate the relative rankings of all the variables and combine them appropriately on the final scale (the higher the score the greater the chance of survival). Finally cross tabulations were performed (for those patients who were resuscitated for more than 15 minutes) based on the dependent variable "survival to 24 hours" against patients total odds ratio scores, thereby producing a specific prediction of survival for each set of variables.

RESULTS

Of the 1633 in the study group no patients were lost to follow up. A total of 661 (41%) patients survived for at least 20 minutes after resuscitation. Survival to 24 hours was 444 (28%) and the survival to discharge from hospital was 297 (19%) patients.

Patient variables: pre-arrest factors

The patients age ranged from 20 to 100 years, with a mean of 72 (SD 12.54). With age as a continuous variable immediate survival was highly significant ($p < 0.001$). As a dichotomous variable those less than 70 years were significantly more likely to survive ($p < 0.001$).

There were 977 (60%) male arrests and 654 (40%) female arrests. Immediate survival according to sex just reached significance ($p = 0.05$) the survival rate for women (43%) being higher than for men (39%).

As required for Utstein guidelines⁸ the admission diagnosis was categorised as either cardiac (medical and surgical), non-cardiac (medical), or as a surgical admission. In 261 cases the admission diagnosis was not identified, in the remaining 1372 the survival rate was 41% (293 of 723) for the cardiac (medical and surgical) admissions; 41% (232 of 567) for non-cardiac (medical), and 33% (27 of 82) for the surgical admissions. Although not statistically significant ($p = 0.376$) the survival rate was lower for those with a surgical admission diagnosis.

The study also considered those patients on whom resuscitation had not been started within three minutes of an arrest. Data were missing on 59 patients, of the 1574 remaining, resuscitation was started within three minutes in 1472 (94%) and was begun after three minutes for the remaining 102 (6%). Of these 102 patients only 35 (34%) were initial survivors compared with 598 (41%) from the <3 minute group, a difference however that was not statistically significant ($p = 0.251$).

Figure 1 In hospital Utstein style template: outcome where initial monitored rhythm was VT/VF.

Arrest variables: factors during resuscitation

The primary arrest mode (respiratory or cardiac) was unknown in 98 cases; of the remainder (1535) 19% were identified as respiratory and 81% as cardiac. Immediate survival for patients who had a primary respiratory arrest was significantly higher (56%) than for those who had a primary cardiac arrest (36%) ($p < 0.001$). Survival to 24 hours was also statistically significant for respiratory cases (36%) compared with cardiac (27%) ($p = 0.001$).

The primary arrhythmia was not identified in 238 cases. Survival rates related to rhythm are illustrated in figure 1 and table 1. Immediate survival rates were significantly higher where the primary arrhythmia had been VT or VF ($p < 0.001$). As in the earlier report from our own institution⁹ PEA was the most common primary arrhythmia (43%).

The duration of the resuscitation attempt was found to be an essential factor for immediate survival. The time was recorded in 1513 (93%) cases with a range of <1 minute to 120 minutes, a mean of 15.6 and a median of 15 minutes. Of the survivors 62% were resuscitated in less than 14 minutes with only 20% surviving if the resuscitation lasted more than 15 minutes. As an interval variable duration was highly significant ($p \leq 0.001$), as a categorical variable the duration was highly significant at 15 minutes ($p \leq 0.001$).

Logistic regression analysis

A total of 287 cases were excluded because of missing data leaving 1346 in the model. The factors retained were duration ($> \text{or} < 15$ minutes), primary arrhythmia (VT, VF, asystole, or PEA), age group ($> \text{or} < 70$ years), and the primary mode of arrest (respiratory or cardiac). Rejected from the model were basic life support within three minutes and sex. The dependent variable was survival to 24 hours, which gave the highest

Table 2 RPS Scale

Variables	Odds ratio ("the weighting")	Alive 24 hours (%)	Total (number of patients in each category)
Scale A Survival rates for CPR attempts beyond 15 minutes where the primary mode of arrest (respiratory/cardiac) is not known			
PEA/Asystole + ≥70 years	1	4.8	357
PEA/Asystole + ≤69 years	6	8.4	176
VT/VF + ≥70 years	7	14.1	142
VT/VF + ≤69 years	12	28.8	66
Scale B Survival rates for CPR attempts beyond 15 minutes where the primary mode of arrest (respiratory/cardiac) is known			
PEA/Asystole + ≥70 years + primary cardiac	1	3.8	289
PEA/Asystole + ≤69 years + primary cardiac	6	6.1	131
PEA/Asystole + ≥70 years + primary respiratory	20	9.6	52
PEA/Asystole + ≤69 years + primary respiratory	25	16.7	36
VT/VF + ≥70 years + primary cardiac	7	12.1	132
VT/VF + ≤69 years + primary cardiac	12	28.3	60
VT/VF + ≥70 years + primary respiratory	26	28.6	7
VT/VF + ≤69 years + primary respiratory	31	—*	—*

*Insufficient data.

predictive accuracy. We could not accurately predict survival to discharge from the model, presumably because of the multitude of additional factors that influence survival in the post-resuscitation phase.

Resuscitation Predictor Scale (RPS Scale)

Given that the intention of this research was to produce a predictive scale to be used at the 15 minute interval, a cross tabulation of predicted outcome (from the regression analysis) by the actual outcome of all those cases where the duration of the CPR had lasted 15 minutes or more was produced (n=800–59, missing cases =741). In 658 cases (90%) where death was predicted the patient did not survive, leaving 10% of cases where death was predicted and the patient survived for 24 hours. In other words the predictive accuracy of the final model for cases lasting 15 minutes or longer is 90%.

The RPS Scale was based on the variables from the logistic regression model and survival rates for those patients who were resuscitated for more than 15 minutes. A detailed version of the RPS Scale is shown in table 2 (Scale A and B) and the final version of the scale in appendix 1 (see the journal web site emjonline.com).

DISCUSSION

This study is one of the largest single site on record, with a sample of 1633 CPR attempts. A valid comparison is the recent UK national study¹⁰ of 1368 cases from 49 hospitals. The discharge survival rate was 18% compared with 19% in this study. Survival rates were also similar to BRESUS¹¹ where immediate survival of in hospital arrests were 45%, with 41% in Plymouth, 24 hour survival was 32% to 28%, and discharge survival was 21% to 19% respectively. In these comparative studies multiple re-arrests are included in some form. This is an important factor as it inevitably increases the overall survival rate. As required for Utstein guidelines⁸ we have removed all multiple arrests and treated them as a separate case load.

There was a wide age range in the study with a significant proportion (39%) in their 70s. As in other reports^{10–13} 70 years was a significant statistical cut off point for survival. Setting an age limit on resuscitation would be inappropriate, but combined with other factors it is a guide to survival.

Basic life support should be started within the first three minutes of cardiac arrest.^{10–12} Inhospital basic life support should be started immediately; in this study only 7% were delayed for a relatively short period, which is probably why as a predictor of survival this variable was not statistically significant.

In BRESUS¹¹ those patients whose primary mode of arrest was respiratory were more likely to survive (47%), compared with primary cardiac arrests where the survival rate was lower (42%). These results match our own; we found that patients who had a primary respiratory arrest were significantly more likely to survive (56%) compared with primary cardiac (36%). A good example would be an asthmatic patient, where there is no cardiac abnormality. With prompt CPR they will perhaps be easier to resuscitate than a patient who has arrested after a myocardial infarction.

As in many other reports^{9–12 14} patients who had suffered VT/VF arrests were significantly more likely to survive than those who had asystolic/PEA arrests. However, the most common primary arrhythmia was PEA, 43%.

Supported by other studies^{9–12 15} the duration of the resuscitation attempt was an important factor in predicting survival where there was no return of spontaneous circulation (ROSC); becoming highly significant at 15 minutes (<0.000). If there is a ROSC, at any stage of resuscitation, the latest consensus opinion indicates that it may be appropriate to consider extending the resuscitative effort.⁶

The RPS Scale

Decisions to terminate resuscitation attempts are often subjective and are inevitably based on a myriad of factors, the final decision being the responsibility of the doctor in charge after consultation with the team. We wanted to increase the objectivity of the decision by developing a validated statistical measure from which a resuscitation team could evaluate the chances of survival, at a specific time interval, during the resuscitation attempt.

The final scale (appendix 1 (see journal web site)) is made up of three tables, table A is based on the primary arrhythmia and the patients age, factors that are usually available to decision makers at an inhospital resuscitation. Table B includes the primary arrhythmia and the patients age but also the primary mode of arrest (respiratory/cardiac). The latter is not always known so this table should only be used where the mode of arrest has been identified. Finally Table C lists additional variables, from other studies^{1–3 9–12 14 16–19} that should be taken into account before terminating a resuscitation. Resuscitation teams should first consider using the tool 15 minutes into a resuscitation. It can be used at a later stage but the survival rates illustrated are likely to be reduced.

It is clear from the final scale that the percentage survival is directly related to the weighting score (table 2) and correlated appropriately to each variable. For example, in Scale A a patient of 80 years in asystole is significantly less likely to survive than a patient of 60 years in VF. The variables selected for

use within the scale have a predictive accuracy of 90%, a high figure considering the limited number of key factors. The survival rates listed are taken from a single hospital site, for resuscitations that lasted more than 15 minutes ($n=741$). However, we would argue that these figures are reasonably representative of in-hospital resuscitation in the United Kingdom. Our survival rates are matched by the national BRESUS study,¹¹ our predictors of survival have been validated in many other studies,^{1-3 9-12 14 15} and we comply with Resuscitation Council (UK) guidelines for the management of cardiac arrests.

In developing the RPS Scale we have been able to demonstrate that 15 minutes into a resuscitation is an acceptable point at which to first consider termination (where there has been no ROSC). For example, an 80 year old whose primary arrhythmia was asystole has a very poor chance of survival (5%). Clearly however there are important ethical issues involved in using such a tool, in some situations a 5% chance of survival would be deemed sufficient to continue resuscitation. In another situation the clinician may have substantial evidence to support cessation of resuscitation where the RPS Scale indicates that there is a 29% chance of survival. However, we have been able to meet our objectives with the production of an accurate tool for clinicians that should be used to aid resuscitation termination decisions.

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Contributors

Simon Cooper initiate the research, discussed core ideas, participated in the protocol design and coordinated and assisted in the data collection. He assisted in the analysis and interpretation of the data and wrote and edited the paper. Chris Evans discussed core ideas, participated in the protocol design, undertook the data entry, assisted in the data analysis and edited the paper. Steve Shaw advised on and approved the statistical techniques. The guarantor of the paper is Simon Cooper.

Additional information relating to this paper is on the journal web site (emjonline.com)

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