The Development of a Simple Risk Score to Predict Early Outcome in Severe Acute Acidotic Cardiogenic Pulmonary Edema

The 3CPO Score

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Background—Acute cardiogenic pulmonary edema is a common medical emergency with high early mortality. Initial clinical assessment would benefit from accurate mortality prediction. We aimed to develop a simple clinical score based on presenting characteristics that would predict 7-day mortality in patients with acute cardiogenic pulmonary edema.

Methods and Results—We used data from patients recruited to the 3CPO trial (a pragmatic multicenter trial comparing continuous positive airway pressure, noninvasive positive pressure ventilation, and standard oxygen therapy in emergency department patients with acute cardiogenic pulmonary edema) to investigate the association between baseline characteristics and 7-day mortality. Factors associated with mortality ($P<0.1$) were entered into a multivariable model. Independent predictors of mortality from the multivariable model ($P<0.05$) were assigned integer weights based on their coefficients and incorporated into a risk score. The discriminant ability of the score was tested by receiver operator characteristic analysis. Data from 1069 patients (78±10 years; 43% men; 7-day mortality, 9.6%) were analyzed. Multivariable analysis identified age ($P=0.003$), systolic blood pressure ($P<0.001$), and Glasgow Coma Scale motor component dichotomized and simplified to the ability to obey commands or not ($P=0.02$) as the only independent predictors of 7-day mortality. These were weighted and used to develop a risk score ranging from 0 (7-day mortality, 1.9%; 95% CI, 0.8 to 4.5) to 7 (7-day mortality, 100%; 95% CI, 34.2 to 100). Receiver operator characteristic analysis demonstrated good risk prediction with a c-statistic of 0.794 (95% CI, 0.745 to 0.843). A simplified 3-point score with no weighting had a c-statistic of 0.754 (95% CI, 0.701 to 0.807).

Conclusions—A simple clinical score based on age, systolic blood pressure, and the ability to obey commands predicts early mortality in patients with acute cardiogenic pulmonary edema.

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Key Words: heart failure ■ prognosis ■ mortality ■ risk factors ■ edema

Admissions to hospital with acute decompensated heart failure are increasing and are the commonest reason for hospital admission in patients older than 65 years.[1,2] Patients admitted with this condition have high short- and long-term mortality.[3,4] This has led some authorities to compare the burden of disease to that of acute myocardial infarction.[5] Approximately 50% of patients admitted with acute decompensated heart failure will present with acute cardiogenic pulmonary edema (ACPE) as the principal finding.[6]

Clinical Perspective on p 117

ACPE is a life-threatening medical emergency. Early management includes high flow oxygen, nitrate, and diuretic therapy.[7] Patients who do not respond to medical treatment may require noninvasive ventilation or endotracheal intubation.[8–10] Response to treatment may be rapid and unpredictable. Many will quickly improve and can be appropriately managed with a relatively short inpatient stay on a general ward. Others will require admission to coronary, high dependency, or intensive care. A significant proportion (around 10%) will die during hospital admission despite treatment.[3,4,11]

Initial clinical management may be improved by the rapid and accurate estimation of early mortality through guiding emergency treatment and prognostication. A number of

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scores have been developed to enable outcome prediction but none relate directly to patients with ACPE presenting to the emergency department.[12–14] Cohorts have included all hospitalized patients with acute heart failure syndromes rather than specifically patients with ACPE or concentrated on identification of low-risk groups.[15] Indeed, it is increasingly accepted that there are a number of different pathophysiological presentations within cohorts of patients with acute heart failure syndromes and treatments should be tailored and outcomes may differ between these.[16,17] Previous risk scores have included predictor variables (comorbidities, etiology, laboratory tests, and cardiac function) that are not consistently available before immediate treatment and decision making at presentation[17–19] and used outcomes that may not be directly relevant to emergency care settings. When tested, they have been shown not to perform adequately in the emergency department setting.[20]

We have recently reported a large multicenter trial comparing noninvasive ventilation (continuous positive airway pressure or noninvasive positive pressure ventilation) to standard therapy for ACPE with acidosis (the 3CPO trial).[21] This pragmatic trial provided an opportunity to develop a tool for predicting early mortality in ACPE. We aimed to develop a simple clinical score based on presenting characteristics that could be used to predict 7-day mortality in patients with ACPE.

Methods

This is an analysis of the previously reported 3CPO trial.[21] Patients were recruited from 26 emergency departments in the United Kingdom who presented with acute cardiogenic pulmonary edema. Inclusion criteria were age >16 years, clinical diagnosis of acute cardiogenic pulmonary edema, pulmonary edema on chest radiograph, respiratory rate >20 breaths per minute, and arterial hydrogen ion concentration >45 nmol/L (pH <7.35). Exclusion criteria were a requirement for a lifesaving or emergency intervention such as primary percutaneous coronary intervention, inability to consent, and previous recruitment into the trial. Eligible patients were consented and then randomized using a telephone randomization service to standard oxygen therapy, continuous positive airway pressure, or noninvasive positive pressure ventilation on a 1:1:1 basis. Other concomitant therapies were administered at the discretion of the treating clinician, but the trial guideline advocated the use of nitrates. The intervention arms were delivered for a minimum of 2 hours, but the treating clinician was free to change the treatment if he/she felt it was clinically appropriate. There were no prespecified treatment failure or endotracheal intubation criteria. Primary end points were 7-day mortality for the comparison between noninvasive ventilation (continuous positive airway pressure or noninvasive positive pressure ventilation) compared with standard oxygen therapy and a combined end point (7-day mortality or endotracheal intubation) for the comparison between continuous positive airway pressure and noninvasive positive pressure ventilation. There were a number of secondary outcomes that included a comparison of myocardial infarction rates between groups. Data collected included patient epidemiological, historical, and physiological characteristics; interventions such as endotracheal intubation; mortality; myocardial infarction; length of stay; critical care admission; and patient symptoms measured by a dyspnea scale. All patients, if possible, were approached for repeat consent within 7 days of recruitment and subsequently followed up to 6 months after recruitment. The trial received Multicenter Research Ethics Committee approval (MREC/02/0/74) and was registered.

Data Analysis

Univariate analysis was used to identify significant associations ($P<0.1$) between each of the following variables and 7-day mortality: age, sex, history and comorbidities, baseline physiology, arterial blood gas variables, Medical Research Council breathlessness scale breathlessness score,[22] and acute breathlessness measured on a 0 to 10 visual analogue score. χ^2 tests were used for categorical variables, and t tests were used for continuous variables. The Glasgow Coma Scale (GCS)[23] was dichotomized into normal versus abnormal for each element because most patients had a normal GCS as determined by the trial inclusion criteria.

Variables with a significant association ($P<0.1$) with mortality were entered into a multivariable model. Factors shown to be independent predictors of outcome ($P<0.05$) were selected for development of a clinical score. Continuous independent predictor variables were categorized into septiles, and the relationship of the categorized variables with mortality was examined to simplify the number of categories. The simplified independent predictor variables were subsequently entered into a multivariable logistic regression model to estimate the strength of the independent association of each variable with mortality, as expressed by the logistic regression coefficients. Interaction terms for each possible combination of variables were then added to the model to determine whether there were any significant interactions between predictor variables. We also ran a stepwise backward elimination procedure, starting with all the variables with a significant univariate association with outcome, and using $P>0.05$ to eliminate variables from the model, to check whether this produced the same set of independent predictor variables for the final model.

For each variable found to be an independent predictor of outcome, we assigned integer weights to each category of that variable to produce an overall score that would be easy to use in clinical practice. The weights corresponded approximately to the relative magnitude of the coefficient for the category in the multivariable model. A weight of 0 was assigned to the category with the lowest mortality for each variable. The integer weights for each variable were summed to obtain the total score for each patient.

The performance for this derivation cohort of the score was then investigated by reporting the association between the score and 7-day mortality. We also compared mortality in patient groups with the same overall score but derived in different ways from the individual elements to ensure that the score was internally consistent. This check examines whether clinically distinguishable groups with the same risk prediction score do in fact have similar outcomes. To check the second requirement of a clinically useful risk prediction score, that patients with higher scores should be at greater risk than patients with lower scores, we calculated the area under the receiver operator characteristic curve (the c-statistic). This statistic can be interpreted as the probability that a randomly selected patient who died had a higher risk prediction score than a randomly selected patient who survived.

Finally, we analyzed the performance of a more simplified version of the score using unweighted variables, ie, each variable was dichotomized and weighted as either 1 or 0. The difference in the c-statistic of the weighted score and unweighted score was compared using the Roccomp procedure in Stata.

Results

Patient flow through the trial has been reported elsewhere[21] (Supplemental figure I). Data from the 1062 patients with 7-day mortality recorded were available for analysis. Patients were elderly (age, 78±10 years), predominantly women (57%), and unwell with a marked tachycardia (112±22 beats per minute), tachypnoea (32±7 respiratory rate per minute), hypertension (systolic blood pressure [BP], 161±36 mm Hg), acidosis (pH, 7.22±0.09), and hypercapnia (pCO_2, 7±2.3 kPa). There was a high 7- and 30-day mortality (9.6% and 15.6%, respectively). Data on the cause and timing of death

Table 1. Cause and Timing of Deaths

Cause of Death	Within 48 h	48 h to 7 d	Within 7 d	Within 30 d
Cardiovascular	34 (68.0)	39 (75.0)	73 (71.6)	112 (70.4)
Cerebrovascular	2 (4.0)	0	2 (2.0)	4 (2.5)
Renal	1 (2.0)	0	1 (1.0)	1 (0.6)
Respiratory	10 (20.0)	11 (21.2)	21 (20.6)	30 (18.9)
Sepsis	1 (2.0)	0	1 (1.0)	1 (0.6)
Mixed	1 (2.0)	1 (1.9)	2 (2.0)	4 (2.5)
Not recorded	0 (0)	1 (1.9)	1 (1.0)	1 (0.6)
All causes	48	54	102	159

Data are presented as n (%).

after presentation are detailed in Table 1. Fifty-one percent of patients were diagnosed with an acute myocardial infarction during admission, 2.8% were intubated, and 41.6% were admitted to a critical care bed on leaving the emergency department. Median length of stay was 9 days.

Age, previous coronary heart disease, hypercholesterolemia, GCS verbal component, GCS motor component, Medical Research Council breathlessness scale score, systolic BP, arterial acidosis, and oxygen saturation were associated with increased 7-day mortality ($P<0.1$; Table 2). These variables were entered into the multivariable model and age ($P=0.003$). Systolic BP ($P<0.001$) and GCS motor component ($P=0.02$) were the only independent predictors of 7-day mortality (Table 3). These were selected for development of a clinical score. The backward elimination procedure also removed all the variables except these 3 confirming that the model selected was the best one for this dataset.

GCS motor component was incorporated as a dichotomized variable and simplified to either the ability to obey or not to obey commands. The relationships between mortality and septiles of age and systolic BP are shown in Supplemental Figures II and III. On the basis of this analysis, age was categorized as ≤75 years, 76 to 85, or >85, and systolic BP was categorized as ≤120 mm Hg, 121 to 140 mm Hg, or >140 mm Hg. These 3 categorical variables were entered into a multivariable model. No significant interactions were identified between the variables. The coefficients for each category are detailed in Table 4. Integer weights were assigned to each variable category based on the relative magnitude of the coefficient for the category in the multivariable model (main effects only) to produce a score that would be easy to use in clinical practice (Table 5). Table 6 shows mortality for each level of the score. Mortality increases as the score increases.

Outcomes for clinically distinguishable groups with the same score are shown in Figure 1. Each dot shows the mortality for a group of patients who share the same score and the same value on each of the 3 elements of the score. Different dots at the same overall score show mortality for patients with the same overall score but different scores on the 3 elements. For example, the same overall score of 2 is shared by patients with normal systolic BP who are older than 85 years and able to obey commands or younger than 75 years but unable to obey commands. Although there are differences

Table 2. Univariate Analysis

Characteristic	Alive at 7 d (n=960, Except Where Shown)	Dead at 7 d (n=102, Except Where Shown)	*P*
Male	413 (43.0%)	46 (45.1%)	0.687
Previous coronary heart disease	598 (62.3%)	55 (53.9%)	0.099
Previous heart failure	416 (43.3%)	47 (46.1%)	0.595
Valvular heart disease	102 (10.6%)	8 (7.8%)	0.381
Known chronic obstructive pulmonary disease	169 (17.6%)	21 (20.6%)	0.455
Previous cerebrovascular accident	155 (16.1%)	22 (21.6%)	0.162
Previous peripheral vascular disease	93 (9.7%)	12 (11.8%)	0.504
Hypertension	530 (55.2%)	48 (47.1%)	0.116
Diabetes	293 (30.5%)	33 (32.4%)	0.703
Hypercholesterolemia	301 (31.4%)	22 (21.6%)	0.041
Smoker	172 (17.9%)	12 (11.8%)	0.119
Ex-smoker	371 (38.6%)	40 (39.2%)	0.911
Normal baseline verbal GCS	808/893 (90.5%)	76/96 (79.2%)	0.001
Normal baseline eye GCS	804/899 (89.4%)	82/96 (84.5%)	0.231
Normal baseline motor GCS	883/903 (97.8%)	86/96 (89.6%)	<0.001
MRC score not recorded	367 (38.2%)	47 (36.1%)	0.009
MRC score 1	80 (8.3%)	5 (4.9%)	
MRC score 2	154 (16.0%)	16 (15.7%)	
MRC score 3	125 (13.0%)	10 (9.8%)	
MRC score 4	161 (16.8%)	8 (7.8%)	
MRC score 5	73 (7.6%)	16 (15.7%)	
Mean age, y	77 (9.7)	81 (9.2)	0.001
Mean (SD) baseline pulse rate, per minute	113 (22)	110 (23)	0.118
Mean (SD) baseline systolic blood pressure, mm Hg	165 (35)	130 (31)	<0.001
Mean (SD) baseline respiratory rate, per minute	32 (6.8)	31 (6.4)	0.164
Mean (SD) baseline oxygen saturation, %	91 (8.1)	89 (8.1)	0.061
Mean (SD) baseline arterial pH	7.22 (0.09)	7.20 (0.09)	0.045
Mean (SD) baseline arterial Po_2, kPa	13.4 (8.2)	12.9 (6.5)	0.577
Mean (SD) baseline arterial Pco_2, kPa	7.60 (2.2)	7.42 (2.7)	0.441
Mean (SD) baseline bicarbonate, mmol/L	20.6 (4.1)	19.9 (6.4)	0.122
Mean (SD) baseline breathlessness, 0 to 10	8.9 (1.6)	8.9 (1.5)	0.894

MRC indicates Medical Research Council breathlessness scale.

Table 3. Multivariable Analysis

	Odds Ratio	Lower 95% CI	Upper 95% CI	*P*
Age	1.042	1.014	1.071	0.003
Previous coronary heart disease	0.689	0.422	1.125	0.136
Hypercholesterolemia	0.809	0.457	1.435	0.469
Normal verbal GCS	0.616	0.292	1.301	0.204
Obeys commands	0.274	0.093	0.810	0.019
MRC score=1	0.685	0.225	2.091	0.165
MRC score=2	0.922	0.460	1.849	
MRC score=3	0.780	0.350	1.738	
MRC score=4	0.585	0.256	1.339	
MRC score=5	2.040	0.977	4.260	
Baseline systolic blood pressure, mm Hg	0.968	0.960	0.976	<0.001
Baseline oxygen saturation, %	0.985	0.957	1.014	0.321
Baseline arterial pH	0.154	0.009	2.573	0.193

MRC indicates Medical Research Council breathlessness scale.

in mortality between some groups with the same total score derived by different combinations, these differences were not statistically significant (χ^2=8.93, *df*=8, *P*=0.35), providing no evidence of heterogeneity of outcome for patients with the same score. Some of the groups in this analysis comprised <5 patients.

The receiver operator characteristic curve for the weighted score showed good discriminant power with a c-statistic of 0.794 (95% CI, 0.745 to 0.843; Figure 2). This was similar to the c-statistic for a model based on using the 7 septile categories for age and BP rather than the 3 categories in the simplified model, and using the actual values for model estimated coefficients rather than integer weights (c-statistic=0.810), suggesting that simplifying the score did not markedly reduce its predictive power.

An even more simplified version of the score was tested with no weights attached to the 3 components, ie, 1 point for patient unable to obey commands, 1 point for age >75, and 1 point for systolic BP ≤140 mm Hg. Mortality for a score of 0 was 1.9% (95% CI, 0.8 to 4.5), for 1 was 6.4% (95% CI, 4.7 to 8.8), for 2 was 25.9% (95% CI, 20.2 to 32.7), and for 3 was 77.8% (95% CI, 45.3 to 93.7). The c-statistic for the receiver operator characteristic curve (Figure 2) was 0.754 (95% CI, 0.701 to 0.807), which was significantly worse than the c-statistic for the weighted score (0.794; χ^2=11.71, *df*=1, *P*<0.001), and there was evidence of heterogeneity in outcomes between clinically distinguishable groups with the same unweighted score (χ^2=28.3, *df*=12, *P*=0.005). However, the clinical value of the slightly better prediction using a more complex score remains the true test.

Table 4. The 3CPO Score Coefficients

	Actual Coefficient	Weighted Integer Coefficient	Unweighted Integer Coefficient
Age ≤75 y	0	0	0
Age 76–85 y	0.719	1	1
Age >85 y	1.136	2	1
Systolic blood pressure >140 mm Hg	0	0	0
Systolic blood pressure 121 to 140 mm Hg	1.562	2	1
Systolic blood pressure ≤120 mm Hg	2.461	3	1
Ability to obey obeying commands	0	0	0
Inability to obey commands	1.682	2	1

Table 5. The 3CPO Score (Weighted)

Age ≤75 y	0
Age 76–85 y	1
Age >85 y	2
Systolic blood pressure >140 mm Hg	0
Systolic blood pressure 121 to 140 mm Hg	2
Systolic blood pressure ≤120 mm Hg	3
Able to obey commands	0
Unable to obey commands	2

Discussion

We have developed a simple clinical score to predict 7-day mortality in ACPE with acidosis based on 3 variables (age, ability to obey commands, and systolic BP) that can be measured immediately at presentation. This score can be used to provide an immediate assessment of the patients' risk for mortality and guide initial management. In its simplest form, the score ascribes 1 point each for inability to obey commands, age >75, and systolic BP ≤140 mm Hg to give a maximum of 3 points. Alternatively, the components can be weighted to give a more precise 7-point score with slightly higher discriminant value and better internal consistency.

Our analysis has identified which presenting variables are predictors of mortality and which are not. Of particular interest is the strong independent predictive value of systolic BP, which has been described in previous registry and trial data.[12–18] Often, the development of acute cardiogenic pulmonary edema is dominated by a marked hypertensive response that is implicated in either its causation or the marked stress response to the clinical condition.[5,24] It is

Table 6. Performance of the 3CPO Score

Score	n/N Dead at 7 d	Mortality (95% CI), %
0	5/257	1.9 (0.8 to 4.5)
1	10/289	3.5 (1.9 to 6.3)
2	17/209	8.1 (5.1 to 12.6)
3	21/114	18.4 (12.4 to 26.5)
4	22/90	24.4 (16.7 to 34.2)
5	13/28	46.4 (29.5 to 64.2)
6	5/7	71.4 (35.9 to 91.8)
7	2/2	100 (34.2 to 100)
Total	95/996	9.5

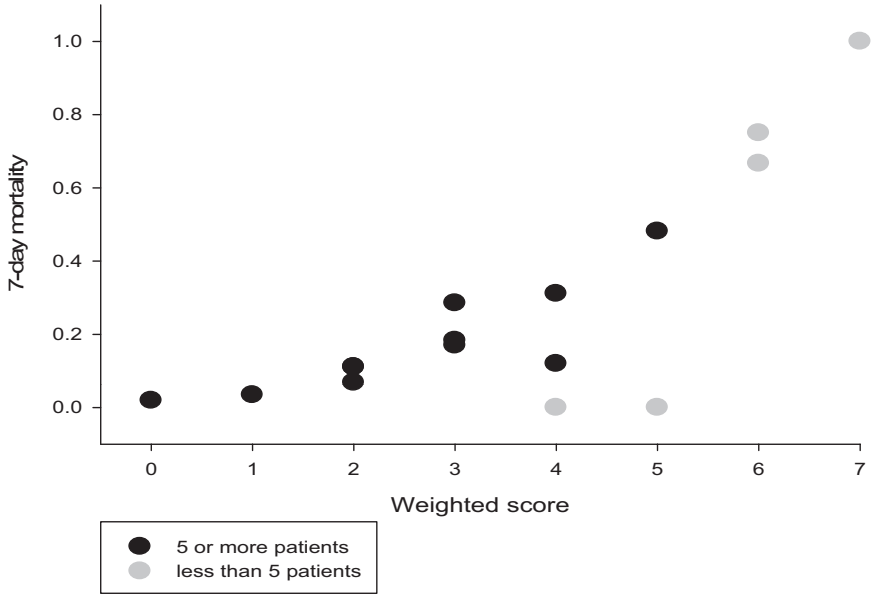

Figure 1. Values of the score from 2 to 6 may be derived from different combinations of the three components (age, systolic BP, and ability to obey commands). The mortality rate for each potential combination of the score is plotted separately to demonstrate whether patients with the same score, derived from different combinations of the constituent elements, may have different mortality rates. Seven-day mortality by weighted score for clinically distinguishable subgroups.

perhaps surprising that history of myocardial infarction, vascular disease, or previous cardiac failure did not independently predict outcome unlike previous findings.[17,18] This may reflect the inaccuracies of history ascertainment at the time of presentation or suggests that such features are poor predictors of early outcome that is dominated more by age and physical and hemodynamic reserve.

Several studies have identified predictors of outcome in acute heart failure,[18] although none have focused specifically on early predictors in ACPE in the emergency department. Lee et al[12] developed a risk score for 30-day and 1-year mortality in community-based patients presenting with heart failure and found that age and systolic BP were independent predictors, alongside respiratory rate, blood urea nitrogen level, hyponatremia, and a number of comorbidities. The c-statistic for 30-day and 1-year scores was 0.80 and 0.77, respectively. Felker et al[13] developed a risk score for 60-day mortality in patients hospitalized for acute heart failure who were recruited into a randomized trial of milrinone versus placebo and found that age, systolic BP, New York Heart Association class IV symptoms, blood urea nitrogen, and sodium were independent predictors. The c-statistic for the predictive model was 0.77. Fonarow et al[14] developed a risk score for in-hospital mortality in patients hospitalized with acute heart failure and found that age and

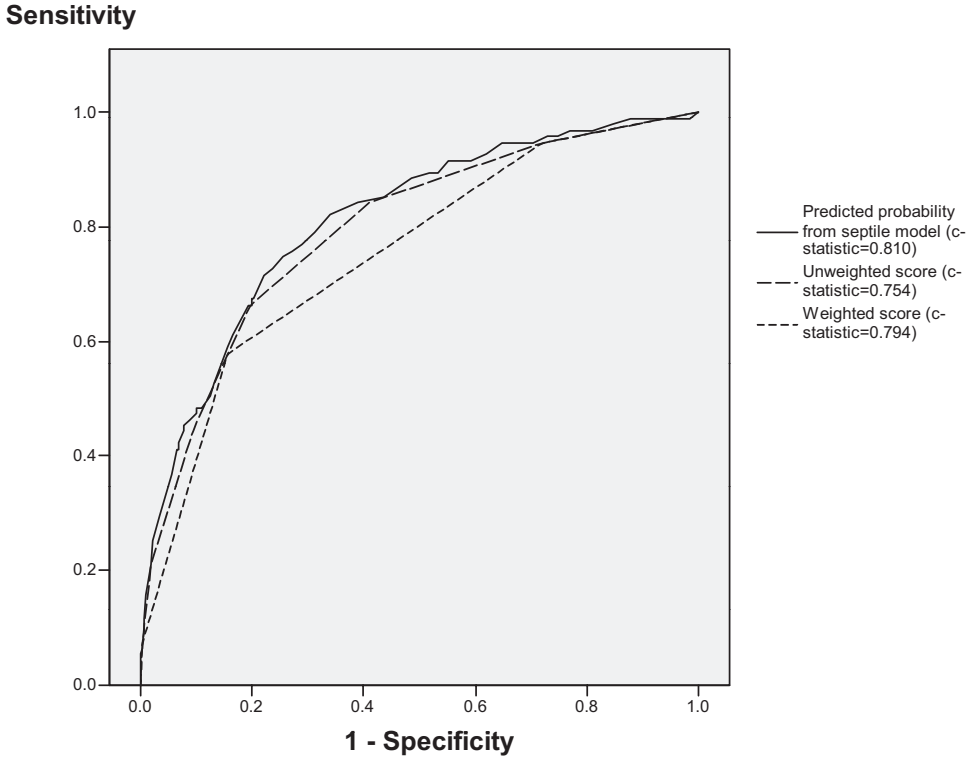

Figure 2. Receiver operator characteristic curves for 3CPO scores, showing predicted probability from septile model (c-statistic=0.810). Unweighted score, c-statistic=0.754; weighted score, c-statistic=0.794.

systolic BP were independent predictors, alongside blood urea nitrogen and heart rate. Recursive partitioning was used to develop a simple risk tree.

We have confirmed that age and BP are independent predictors but have shown that in patients with ACPE and acidosis, the addition of the ability to obey commands provides a risk score with equivalent discriminant power to previous scores. The 3CPO score has additional advantages of being easy to compute and based entirely on clinical data that are immediately available at initial patient assessment. The 3CPO score in conjunction with clinical judgment allows rapid identification of patients who are at high risk for subsequent death and those who are, despite being extremely unwell at presentation, at low risk for death. This enables early decisions to be made regarding the level of therapeutic intervention and the disposition of the patient on leaving the emergency department and in addition may therefore be of value in prehospital care.

A number of limitations need to be considered before using the 3CPO score. First, the generalizability of the score has not been tested in validation cohorts, and therefore, the discriminant value is likely to overestimate the value in other populations. However, the over prediction as a result of both developing and testing the model in the same data are estimated to be only 6%.[25] Second, the 3CPO trial specifically recruited patients with severe ACPE defined by arterial pH <7.35. Therefore, the score should only be applied to patients who are acidotic at presentation. Third, the study did not have adequate power to fully test the internal consistency of higher values for the score, and values of 4 or 5 may lack internal consistency. However, it should be noted that this step is rarely undertaken in the development of risk scores. When internal consistency has been assessed, it suggested that widely used scores may lack internal consistency.[26] Finally, with regard to the clinical utility of the score, it should be recognized that the score simply predicts risk for mortality, with no judgment being made as to whether mortality is preventable or not. Clinical judgment will still need to be used in patients with a high score to determine whether intensive treatment is likely to be worthwhile or futile. This caveat applies to all mortality prediction scores.

In summary, we have developed a simple "bedside" risk score for patients with acute cardiogenic pulmonary edema with acidosis using age, the patient's motor response, and systolic BP that accurately predicts 7-day mortality. This simple score can be used by any health professional to provide an immediate assessment of the risk for early mortality.

Appendix

Recruiting Sites, Clinical Leads, and Patients Recruited

Royal Infirmary of Edinburgh, Alasdair Gray (n=161); Southern General Hospital, Glasgow, Phil Munro (n=23); Ninewells Hospital, Dundee, Neil Nichol (n=21); Crosshouse Hospital, Crawford McGuffie (n=50); Hairmyres Hospital, Kilmarnock, John Keaney (n=28); Northern General Hospital, Sheffield, Steve Goodacre (n=136); York Hospital, Steve Crane (n=63); St James University Hospital, Leeds, Steve Bush (n=56); Leeds General Hospital, Taj Hassan (n=37); Barnsley Hospital, Jane Brenchley (n=54); Harrogate Hospital, Helen Law (n=19); Pinderfields Hospital, Wakefield, Matt Shepherd (n=8); Frenchay Hospital, Bristol, Jason Kendall (n=68); Royal United Hospital, Bath, Dominic Williamson (n=60); Bristol Royal Infirmary, Jonathan Benger (n=32); Royal Devon & Exeter Hospital, Gavin Lloyd (n=39); Torbay Hospital, Torquay, Simon Cope (n=31); Hope Hospital, Salford, Carole Gavin (n=29), Manchester Royal Infirmary, John Butler (n=28); Whiston Hospital, Prescot, Francis Andrews (n=29); Wythenshawe Hospital, Manchester, Darren Walter (n=21); Warrington Hospital, Mary Higgins (n=11); Birmingham Heartlands Hospital, Anthony Bleetman (n=19); Selly Oak Hospital, Birmingham, Peter Doyle (n=30); James Cook University Hospital, Middlesbrough, Patrick Dissmann (n=11); Princess Royal University Hospital, Farnborough, Ian Stell (n=5).

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Disclosures

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CLINICAL PERSPECTIVE

Acute heart failure syndromes are the commonest reason for hospital admission in older patients. Fifty percent of patients admitted with acute heart failure syndromes will present with acute cardiogenic pulmonary edema as the principal finding. Emergency treatment includes oxygen, nitrate, and diuretics. Patients who do not respond to these may require noninvasive ventilation or endotracheal intubation. Many will quickly improve while others will require admission to critical care. Ten percent will die during hospital admission despite treatment. Clinical management pathways may be improved by the rapid and accurate estimation of early mortality. A number of scores have been developed to enable outcome prediction but none relate directly to patients with acute cardiogenic pulmonary edema presenting to the emergency department. In addition, it is increasingly accepted that there are a number of different pathophysiological presentations within cohorts of patients with acute heart failure syndromes and treatments should be tailored and outcomes may differ between these. Previous risk scores have included predictor variables (comorbidities, etiology, laboratory tests, and cardiac function), which are not consistently available at presentation to the emergency department and use outcomes that may not be relevant to emergency care settings. By using data from a recent large multicenter trial comparing noninvasive ventilation (continuous positive airway pressure or noninvasive positive pressure ventilation) to standard therapy for acute cardiogenic pulmonary edema with acidosis (the 3CPO trial), we have developed a simple bedside score using age, blood pressure, and the patients ability to obey commands that accurately and easily risk stratifies patients likelihood of death at presentation. This may be of significant use in primary, prehospital, and emergency settings.

The Development of a Simple Risk Score to Predict Early Outcome in Severe Acute Acidotic Cardiogenic Pulmonary Edema: The 3CPO Score

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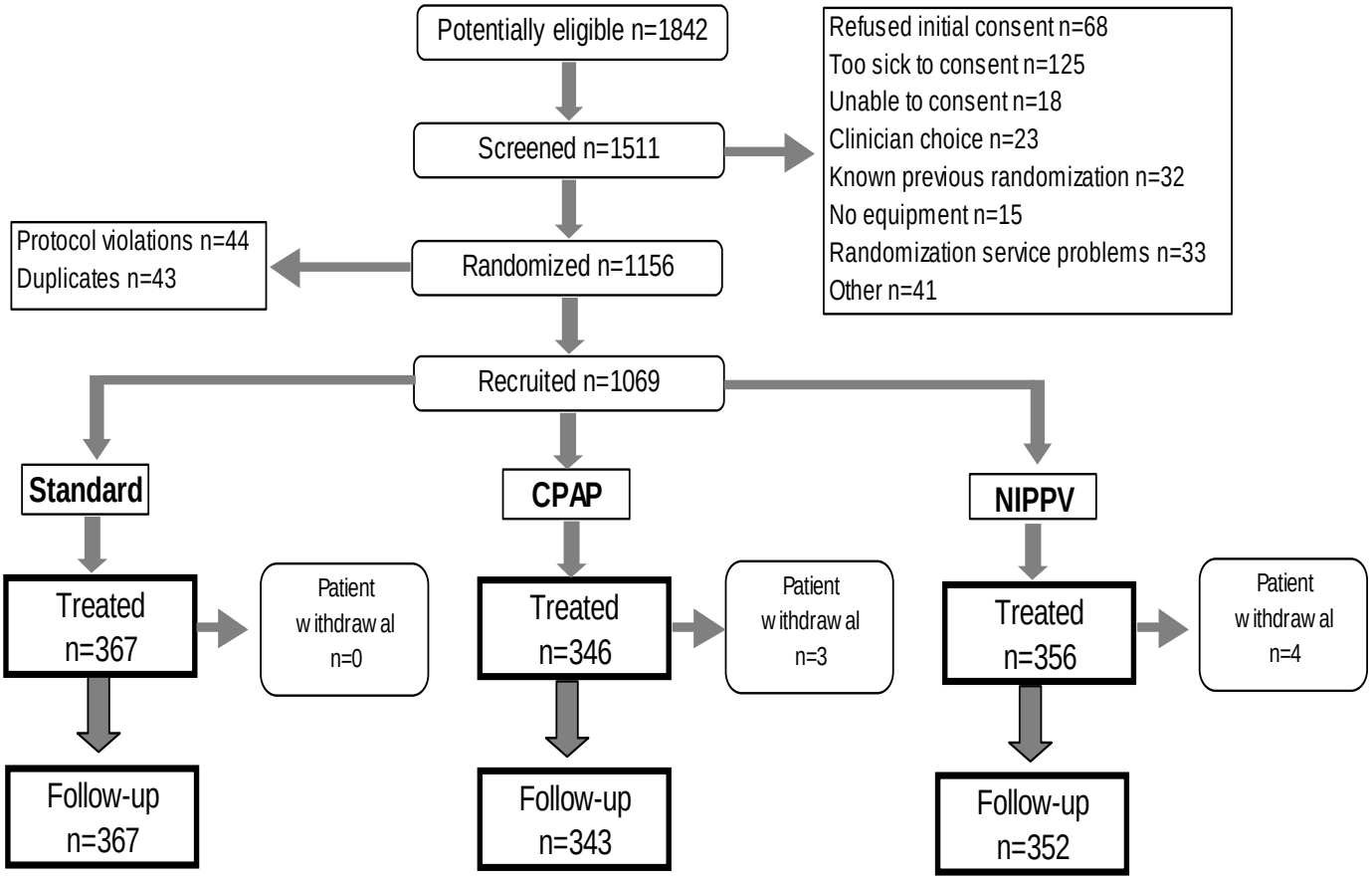
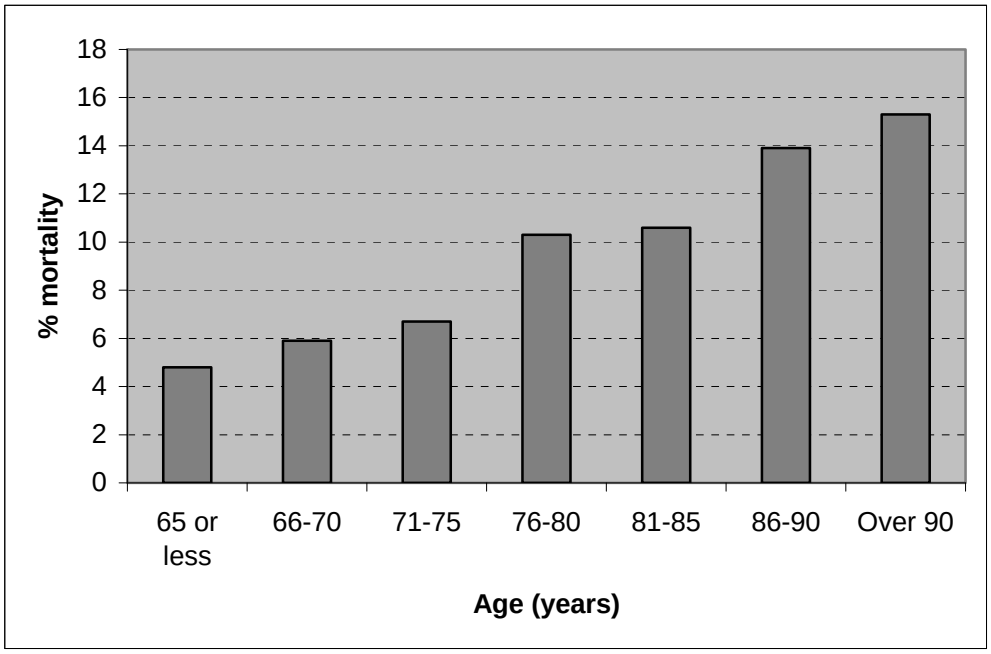
SUPPLEMENTARY MATERIAL

Supplementary figure 1.



Supplementary figure 2.

The association between mortality and septiles of age



Supplementary figure 3.

The association between mortality and septiles of systolic blood pressure