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Reduction in mortality after inappropriate early discharge from intensive care unit: logistic regression triage model

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Abstract

Objective To develop a predictive model to triage patients for discharge from intensive care units to reduce mortality after discharge.

Design Logistic regression analyses and modelling of data from patients who were discharged from intensive care units.

Setting Guy's hospital intensive care unit and 19 other UK intensive care units from 1989 to 1998.

Participants 5475 patients for the development of the model and 8449 for validation.

Main outcome measures Mortality after discharge and power of triage model.

Results Mortality after discharge from intensive care was up to 12.4%. The triage model identified patients at risk from death on the ward with a sensitivity of 65.5% and specificity of 87.6%, and an area under the receiver operating curve of 0.86. Variables in the model were age, end stage disease, length of stay in unit, cardiothoracic surgery, and physiology. In the validation dataset the 34% of the patients identified as at risk had a discharge mortality of 25% compared with a 4% mortality among those not at risk.

Conclusions The discharge mortality of at risk patients may be reduced by 39% if they remain in intensive care units for another 48 hours. The discharge triage model to identify patients at risk from too early and inappropriate discharge from intensive care may help doctors to make the difficult clinical decision of whom to discharge to make room for a patient requiring urgent admission to the unit. If confirmed, this study has implications on the provision of resources.

Introduction

The winter of 1999 highlighted the acute shortage of intensive care beds in the United Kingdom. A consequence of shortage is that patients are often discharged early and perhaps inappropriately to make room for more severely ill patients. A study in 1993 reported mortality after discharge from intensive care from 6.1% to 16.3%.^{1,2} The causes of death after such discharge may be due to factors occurring before^{3,4} or after discharge.⁵⁻⁷ Goldfrad and Rowan, who used

discharges at night as a proxy measure of inappropriate early discharge from intensive care, reported a 1.4-fold increase in ultimate hospital mortality among patients discharged at night.⁸ Patients who died after discharge had significantly higher severity of illness scores or therapeutic intervention scores on the day of discharge than those who survived.^{9,10}

We report on the development of a predictive triage model for discharge to identify patients at risk of dying after discharge from intensive care. We also explored the implications of its use.

Methods

This study was approved by the local ethics committee of Guy's Hospital. We included in the study all patients discharged from the 13 bed intensive care unit at Guy's hospital between 1 June 1990 and 31 December 1998 and from 19 UK units (Riyadh ICU program users group) between June 1989 and September 1996. We analysed daily physiological and treatment data collected prospectively through the Riyadh ICU program (Medical Associated Software House, London) to identify candidate variables for the model. We measured severity of illness and intensity of treatment with the acute physiology and chronic health evaluation (APACHE II) system,¹¹ the organ failure score,¹² and the therapeutic intervention scoring system.¹³ These data, together with demographic data including the presence of chronic ill health (as defined with APACHE II criteria) and patients' hospital outcome, were entered daily on to the computer by a team of specifically trained nurses and doctors.

Model development—There were 6319 patients admitted to the 13 bed general (medical, surgical, and cardiothoracic) adult intensive care unit at Guy's hospital between 30 June 1990 and 31 December 1996. We excluded from the analysis the 844 (13.4%) patients who died on the unit. Only data from the patient's last day in the unit were used to develop the predictive model. We used univariate analysis to identify candidate variables for the model. Variables with a significant influence on survival ($P < 0.05$) after discharge from intensive care were subjected to multivariate logistic modelling. A stepwise forward logistic

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Table 1 Demographic characteristics and clinical features of survivors of intensive care for three datasets. Figure are number (percentage) of patients, median (range), or mean (SD)

	A—Guy's development set		B—Guy's validation set		C—RIP users group*	
	Ward deaths (n=200)	Hospital survivors (n=5275)	Ward deaths (n=49)	Hospital survivors (n=1087)	Ward deaths (n=909)	Hospital survivors (n=6404)
Median age (years)	67 (31-93)	62 (17-101)	70 (27-84)	62 (16-90)	72 (16-96)	63 (16-96)
Men	130 (65)	3676 (70)	32 (65)	727 (67)	507 (56)	3882 (61)
Patients with chronic ill health	79 (40)	1173 (22)	22 (45)	235 (22)	244 (27)	893 (14)
Mean APACHE II score, day 1	19.1 (6.9)	13.5 (5.3)	20.2 (6.1)	14.8 (6.0)	17.3 (6.7)	11.5 (5.9)
Mean last APACHE II score	15.8 (6.1)	11.9 (4.5)	16.9 (5.1)	12.2 (22.2)	15.7 (6.6)	9.8 (5.2)
Mean risk of death, day 1	30.4 (22.6)	11.2 (12.8)	37.3 (21.0)	17.6 (17.3)	29.3 (20.7)	13.7 (14.2)
Mean APP, day 1	13.4 (6.1)	9.6 (4.6)	13.7 (5.5)	10.7 (5.2)	11.5 (6.5)	7.7 (5.2)
Mean last APP	10.1 (5.5)	8.0 (3.7)	10.5 (4.6)	8.1(3.8)	9.9 (6.4)	5.9 (4.4)
Mean OFS, day 1	19.6 (7.3)	13.7 (5.5)	20.0 (7.4)	14.0 (7.0)	17.8 (7.1)	11.7 (6.2)
Mean last OFS	16.1 (6.4)	12.0 (4.6)	17.3 (5.3)	11.9 (5.3)	16.1 (7.0)	9.9 (5.4)
Patients with ≥1 organs in failure at ICU discharge	88 (44)	1252 (24)	26 (53)	333 (31)	495 (54)	2319 (36)
Median TISS points, day 1	34 (4-78)	33 (3-89)	37 (2-93)	43 (20-74)	33 (2-79)	28 (2-93)
Median last TISS points	28 (4-54)	31 (2-79)	33 (20-65)	34 (2-75)	28 (1-75)	23 (1-79)
Cardiothoracic patients	30 (15)	3103 (59)	1 (2)	343 (32)	7 (1)	193 (3)
Ventilated patients	136 (68)	4244 (81)	45 (92)	960 (88)	498 (55)	2658 (42)
Median ventilated days	3 (0-52)	1 (1-260)	7 (1-87)	1 (1-73)	3 (1-53)	2 (1-198)
Dialysed patients	42 (21)	247 (5)	23 (47)	138 (13)	31 (3)	116 (2)
Median dialysis days	4 (1-34)	4 (1-57)	9 (1-45)	4 (1-57)	4 (1-28)	4 (1-75)
Median length of ICU stay	3 (1-64)	1 (1-283)	8 (2-112)	3 (2-79)	3 (1-54)	2 (1-219)
Median length of hospital stay	10 (0-303)	7 (0-677)	10 (1-127)	6 (0-281)	6 (0-256)	9 (0-270)

APP=acute physiology points, OFS=organ failure score, TISS=therapeutic intervention score, RIP=Riyadh ICU program.

regression procedure was used to derive the model. Calibration of the model was assessed by the Hosmer-Lemeshow goodness of fit statistic.¹⁴

Model validation—We evaluated the triage model by applying it to a different dataset. This was derived from 1136 survivors (84.3% of admissions) from the intensive care unit at Guy's hospital who had been admitted between 1 January 1997 and 31 December 1998 and 7313 survivors (76.6% of admissions) from 19 other UK units (Riyadh ICU program users group) who had been admitted between June 1989 and September 1996.

Use of model to alter outcome—For the model to be of any use we must be able to affect the outcome of patients identified as at risk. To test this, we selected patients who had stayed in intensive care for more than three days and had been at risk of death at any time within the 48 hours before discharge from the unit. We excluded from analysis those patients who died on the ward and who had been classified as “not for resuscitation” at discharge from intensive care. The patients were classified into four subgroups: group 0 comprised patients predicted to be at risk on the day of discharge; group 1 comprised patients predicted to be at risk in the 24 hours before discharge; group 2 comprised those predicted to be at risk in the 48 hours before discharge; and group 3 comprised patients who were not at risk in the 48 hours before discharge.

Analysis—Data analysis was performed with the statistical software package SPSS version 9.0. Categorical data were analysed with χ^2 tests. Non-normally distributed continuous data were evaluated with the Mann-Whitney test. Logistic regression analysis was used to develop the predictive model. $P < 0.05$ was considered significant.

Results

Table 1 gives demographic data and details of clinical features, severity of illness, and candidate variables for the model. The following variables were considered in

the models: acute physiology points, length of stay in intensive care, therapeutic intervention score, duration (days) on mechanical ventilation, dialysis, age, presence of chronic ill health, number of failing organs, and whether or not the patient had had cardiothoracic surgery. Acute physiology points was used in preference to APACHE II score as the latter is derived from the acute physiology points, age points, chronic ill health points, and presence or absence of emergency surgery.

Forward stepwise multivariate analyses selected the following five variables: patient's age, chronic health points, acute physiology points at discharge from unit, length of stay in unit, and whether or not the patient had had cardiothoracic surgery for inclusion in the model. A cut off of 0.6 gave the best sensitivity and specificity (65.5% and 87.6%, respectively). In the development dataset mortality in patients identified as at risk was 14% (130/900) while the mortality in those not at risk was 1.5% (70/4575), giving a relative risk of 9.44 (7.12 to 21.51). Details of the final model can be found in the full version of this paper on the *BMJ's* website. The sensitivity and specificity of the two merged validation

Table 2 Comparison of mortality after discharge from intensive care for patients discharged on day of prediction of risk (group 0), patients who stayed additional 24 hours (group 1), patients who stayed additional 48 hours (group 2), and patients at no risk (group 3). Mortality is reduced by 39.3% if patients stay another two days. Figures are number (percentage) of patients

	Alive	Died	Total
Development dataset*			
Group 0	326 (86)	53 (14)	379
Group 1	71 (93)	5 (7)	76
Group 2	52 (96)	2 (4)	54
Combined validation dataset†			
Group 0	581 (72)	230 (28)	811
Group 1	126 (87)	19 (13)	145
Group 2	86 (83)	17 (17)	103
Group 3	776 (96)	34 (4)	810

* $P=0.077$ for group 0 v group 1; $P=0.034$ for group 0 v group 2. † $P=0.0001$ for group 0 v group 1; $P=0.011$ for group 0 v group 2.

What is already known on this topic

In the United Kingdom, the mortality of patients who die on the ward after discharge from intensive care is unacceptably high (9% to 27%)

Indirect evidence has shown that this is due to too early and inappropriate discharge from intensive care that has increased over the past 10 years

What this study adds

A triage model identifies patients at risk from inappropriate discharge from intensive care

Mortality after discharge from intensive care may be reduced by 39% if these patients were to stay in intensive care for another 48 hours

An estimated 16% more beds are required if mortality after discharge from intensive care is to be reduced

datasets were 74.3% and 71.1%, respectively. Mortality in patients identified as at risk was 25% (712/2875) while the mortality in those not at risk was 4% (246/5574), giving a relative risk of 5.61 (4.89 to 6.44).

There were significant differences in mortality after discharge from intensive care between groups 0, 1, and 2 (table 2). In the development dataset the relative risk of mortality for groups 1 and 2 versus group 0 (discharged on the day risk was predicted) was 0.39 (0.18 to 0.83). In the validation dataset the relative risk of mortality was reduced from 6.76 (4.87 to 9.56) in group 0 versus group 3 to 3.46 (2.21 to 5.41) in group 1 and 2 versus group 3. The relative risk of mortality for those who stayed an additional 24 and 48 hours compared with group 0 was 0.512 (0.373 to 0.706).

Potential impact on the provision of intensive care beds—We used the validation dataset to estimate the impact on the provision of intensive care resources. There were 8449 patients who stayed in intensive care for a total of 34 588 days, with an overall mortality after discharge from intensive care of 11.3%. We identified 2875 patients (34% of total) as at risk, with a mortality after discharge of 25%. If we assume that our model is valid, mortality after discharge from intensive care could be reduced by nearly 39% if these patients stayed another two days before discharge. We estimated that this would require 5750 additional intensive care bed days or the provision of fully staffed intensive care bed days would have to be increased by 16%.

Discussion

A considerable number of patients die on the wards after discharge from intensive care units. Mortality after discharge from intensive care ranges from 9% to 27%.^{15 16} Our discharge triage model used objective data (age, end stage disease, physiology, length of stay, and cardiac surgery) in a logistic regression equation to identify patients at risk from inappropriate early discharge. We were able to do this because the database of the Riyadh ICU program captures daily data throughout a patient's stay in intensive care.

UK resources for intensive care

The United Kingdom has limited resources allocated for the provision of intensive care facilities compared with many of its European counterparts,¹⁷ and regional

differences in the number of available intensive care beds have been shown.¹⁸ Although the overall number of intensive care and high dependency beds has increased over the past 10 years, there has been a concurrent rise in hospital activity.^{19 20} Our modelling exercise suggests that up to 34% of patients are at risk and an increase of 16% in the number of intensive care beds is required to avoid deaths from inappropriate early discharges. Although this finding needs confirmation by a prospective study, it is consistent with the finding in the report by the Audit Commission in 1999 that up to 25% (with a median value of 5%) of patients were still being discharged prematurely to allow more seriously ill patients to be admitted.²¹ Neither our discharge triage model nor discharge guidelines published by the Department of Health,²² which deal with the process of care, will have much impact until and unless the shortfall in provision of intensive care beds is corrected.

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Contributors: KD (as part of her PhD) and RWSC (PhD supervisor) collected data and were responsible for data pre-processing, development of the triage model, data analysis, and literature search. KD, RWSC, and RB wrote the paper jointly. RC will act as guarantor.

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Competing interests: R W S Chang designed and developed the Riyadh ICU Program and is a director of Medical Associated Software House, which markets the software.

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