PREDICTION OF PATIENT MORTALITY IN A MEDICAL INTENSIVE CARE UNIT

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SUMMARY

We retrospectively studied the relationship between organ system failure, sepsis, sex, age, length of stay, initial diagnosis at admission, number of organ system failures, pre-existing chronic disease, and mortality in 499 admissions to a medical intensive care unit (ICU) in order to assess their validity to predict the outcome of ICU stay. Mortality referred to death in the ICU only: 160 (32 %) of the 499 patients died in the ICU and 339 (68%) were transferred onto the general medical wards. Sepsis was found to be a good predictor of mortality ($p < 0.01$) as were the other predictors of death, that i.e. is, neurological, cardiovascular and pulmonary failures ($p<0.05$, $p<0.10$, $p<0.10$, respectively).

Key Words : Mortality, Medical Intensive Care Unit

INTRODUCTION

Intensive care units have become one of the most expensive facilities of clinical medicine due to the technical and complex nature of treatments available from highly skilled staff. Patients are transferred to intensive care units (ICU) following the development of a physiological disturbance which cannot be controlled under ordinary ward conditions and thus requires the attention of a skilled staff (1). Since the cost of intensive care medicine is steadily increasing, efficiency of care is becoming more essential (2). Efficacy of care has a direct correlation with patient mortality and, therefore, all units should aim to determine good and bad prognostic factors in order to decrease the mortality rate of their unit.

Patients who respond to treatment are usually transferred from the unit whilst those who are seriously ill often die. The ability of the ICU to support multiple system organ failure (MSOF) frequently postpones inevitable deaths and those who remain after 48 hours continue to present the most difficult prognostic problems (3). Estimating prognosis has long been an important aim of clinical care. To clarify outcome prediction assessed at the beginning of a patient's ICU course, the Acute Physiology and Chronic Health Evaluation (APACHE II) score which provides an accurate measure of physiological disturbance has been developed (4,5). In addition to the APACHE II score the role of sepsis, age, pre-existing chronic disease, single organ system failure (OSF) and MSOF have been studied as prognostic factors (6-11). In this study, our intention was to assess the validity of age, sex, length of stay (LS), the presence of sepsis and organ system failure in order to predict the outcome of ICU stay, therefore, anticipating patiens' prognosis.

PATIENTS AND METHODS

Hacettepe Hospital is a 873 - bed teaching hospital. The medical ICU (MICU) is an 8 - bed area with a nurse/patient ratio of 1:2 and is an integral part of the department of Internal Medicine. Patients from all medical sub-specialities, that is, requiring non-operative procedures and excluding those with myocardial infarctions or primary arrhythmias, are all eligible for treatment in the MICU.

MICU admission records for the period from November 1st 1989 to November 1st 1991 were reviewed by the internal medicine residents using standard forms. During this period 500 admissions were registered. One patient was excluded from the study due to inadequate data, thus 499 patient were included. Charts were reviewed for the following information: age, sex, pre-existing chronic disease, the occurrence of sepsis, OSF, number of OSF during intensive care stay, and LS.

Definitions

A patient was considered septic if there was a bacteriologically proven focus of infection or a positive blood culture. The data for chronic disease and sepsis were considered separately. Criteria for OSF (Table I) were derived from the literature (6,9,11,12); thus if one or more criteria were met during the disease course, the organ system was considered to have failed. Patients with chronic renal insufficiency were considered to have organ dysfunction if there was a two - fold increase in serum creatinine. Neurologic system failure was considered when the Glasgow coma scale value was less than seven in the absence of sedation. If this scale was not available in the records, we used the available neurological status information for estimation [2]. Diabetic ketoacidosis and acute adrenocortical insufficiency were considered endocrine failures. SOSF and MSOF were defined as the dysfunction of one and two or more of the eight evaluated organ systems, respectively. The initial diagnosis was one of cardiovascular, pulmonary, renal, hematological, hepatic, gastrointestinal, and endocrine system problems with or without failure of these organ systems. In this study, mortality refers to death in MICU only.

Statistical Analysis

For continuous variables, means and standard deviations were used, whilst for discrete variables, rates, proportions and ratios were used. Comparisons between groups were made by using t-tests. Risk measures were analysed by odds ratios and multivariate logistic regression.

RESULTS

We studied 499 patients of which 327 were males and 172 were females; the male/female ratio was 1.9:1.0 with ages ranging from 17 to 96 years, with a mean age of 48.67 years. LS ranged from 1 to 50 days with the average LS of all patients being 5.12 days and for survivors 5.43 days. These results are shown in Table II.

Renal and cardiovascular system failures were the two most frequent system failures with rates of 44% and 24% respectively. Mortality rates associated with the afore mentioned system failures are given in Figure 1. Except for renal and endocrine organ failures the mortality rate increased with the presence of organ system failure. For renal and endocrine organ failures, as well as for gastrointestinal system (GIS) failure were not significant. For the remaining system failures the difference between the mortality rates of subjects with and without these organ failures the differences between mortality rates of subjects with and without organ system failures were significant ($p < 0.03$). The risk of death associated with each organ system failure was studied by using the odds ratios; which are given in Table III.

The multivariate logistic regression equation included 15 explanatory variables, with the result being the dependent variable (died-survived). The multivariate

Table I. Criteria for organ system failure [6,9,11,12]

Organ System	Criteria
Cardiovascular	MAP < 50 mm Hg; need for volume loading and/or vasoactive drugs to maintain systolic arterial pressure > 100 mm Hg; heart rate ≤ 50 beat/min; ventricular tachycardia/fibrillation; cardiac arrest; acute myocardial infarction
Pulmonary	Respiratory rate ≤ 5 breath/min or > 50 breath/min; mechanical ventilation for ≥ 3 days or PEEP > 5 cm H_20
Renal	Serum creatinine ≥ 3,5 mg/dl; dialysis
Neurological	Glasgow Coma Scale ≤ 6, in the absence of sedation
Hematologic	Hct < 20%; leukocyte count <0.3 x 10^9 /L; thrombocyte count ≤ 50 x 10^9/L; disseminated intravascular coagulation
Hepatic	Clinical jaundice or total bilirubin level ≥ 3 mg/dl in the absence of hemolysis; serum glutamic-pyruvic transaminase > 2 x normal; hepatic encephalopathy
Gastrointestinal	Stress ulcer necessitating transfusion of > 2 U of blood/h; hemorrhagic pancreatitis; acalculous cholecystitis; necrotizing enterocolitis; bowel perforation
Endocrine	Diabetic ketoacidosis; nonketotic hyperosmolar coma; acute adrenocortical insufficiency; pituitary apoplexy; myxedema coma

MAP : Mean arterial pressure; PEEP = Positive end-expiratory pressure.

Table II. Statistics for continuous explanatory variables

	ALL CASES n = 499		SURVIVORS n = 399		NON-SURVIVORS n = 160		P
Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.	
Age	48.67	17.11	46.40	16.70	53.48	17.95	< 0.001
Length of stay	5.12	4.85	5.43	4.85	4.48	4.87	< 0.05

S.D. = Standard deviation.

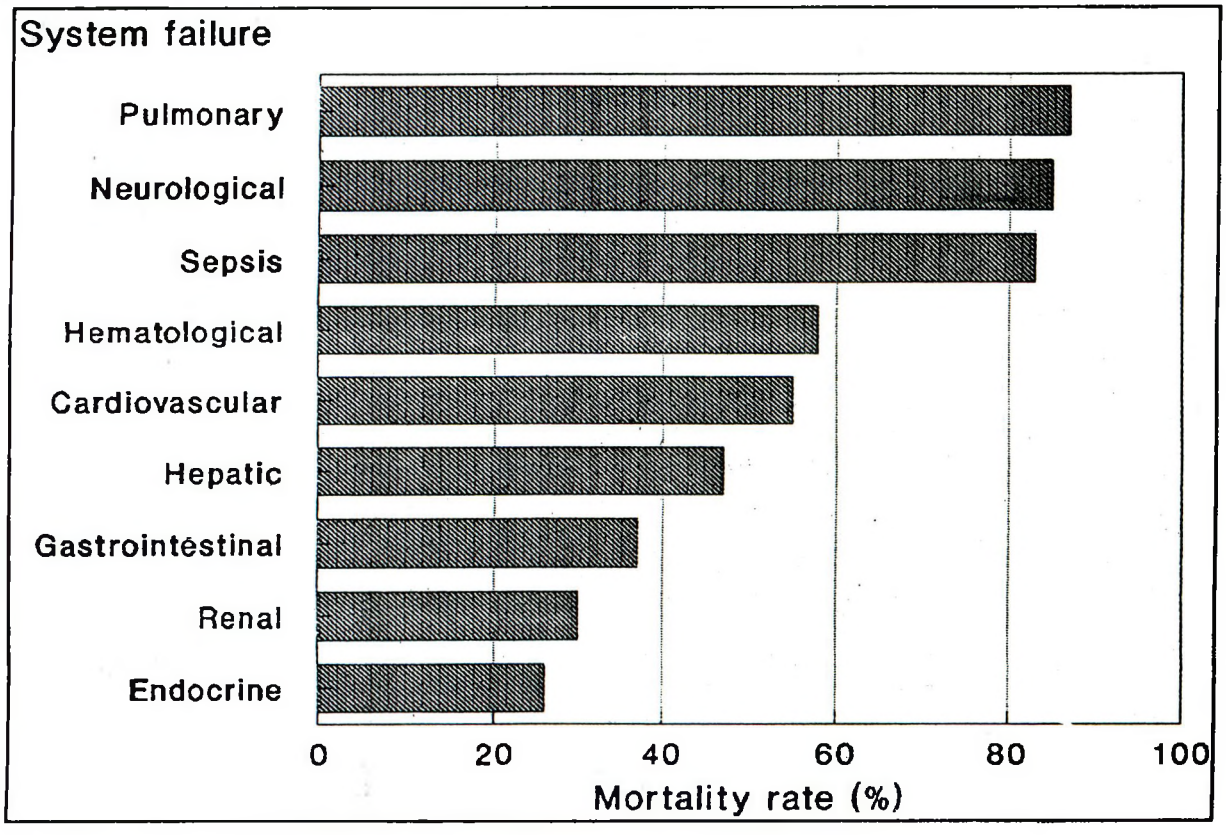

Fig. 1 Mortality rates in descending order associated with system failures and presence of sepsis.

logistic function coefficients related to the 15 explanatory variables are given in Table IV. The most important variable was the presence of sepsis ($p < 0.01$). The others were neurological, cardiovascular and pulmonary failure ($p < 0.05$, $p < 0.10$, $p < 0.10$ respectively).

The probability of death at various levels for predictor variables which are found to be significant, while fixing the other predictors at their mean values (adjusted logit model) are given in Table V. When the probability of death of 0.50 is taken as the cut-off point the sensitivity of the model is 0.70 and the specificity is 0.94.

DISCUSSION

In some patients admitted to MICU serious complications may emerge, leading to the intensification of physiologic and mechanical support services. As a consequence, the interpretation of changes in clinical conditions by doctors and the perception of clinical changes by the patients' families will differ. Therefore, a specific and sensitive model of patient outcome will help all groups involved.

Not surprisingly, the older patients had higher mortality rates compared to the younger ones, but in the logistic regression model age did not carry an independent risk and neither the presence of prior chronic disease. The impact of age and prior chronic diease on mortality varies between studies [1,6,11]. Tran et al. [6] found that advancing age and preexisting chronic disease were risk factors for sepsis which independently contributed to mortality. These results are compatible with Manship et al. [11]. The combined contributions of age and sepsis to patient mortality and their roles, as a whole in the logistic regression model, were not analysed.

In this study, as we reported previously [13], the initial diagnosis at ICU admission and LS in the ICU does not contribute to mortality. Latour et al. [1] reported that length of stay in the ICU of more than ten days carried a bad prognosis. Knaus et al. [2] found that in acute organ system failure the duration of organ failure closely correlated with the mortality. Our results for LS and mortality rates seem to be in contradiction with the literature reviewed. This difference was thought to be due to the non-admission of trauma, burns, and postoperative patients to our MICU whereas Knaus el al. [2] studied mixed medical/surgical ICU's.

Among the organ system failures, cardiovascular, respiratory and neurological failures had the worst prognosis (Table IV, V). However, the impact of cardiovascular failure on mortality varies between studies [6,11]. Many of our patients were admitted because of cardiovascular or respiratory insufficiency often followed by progression to cardiopulmonary failure. Tran et al. [6] also reported higher mortality rates among patients with cardiopulmonary failure. An interesting finding of the present study is the predictive value of neurological failure in defining the outcome, patients with a serious neurological deficiency had a mortality probability of 77%, whilst in other patients with normal neurological functions this value was 20%. The mortality rate was 85% and the odds ratio was 17.16 in patients with neurological deficiencies. One factor responsible for higher mortality was the associated sepsis and other organ failures with neurological deficiencies. In each of the patients with neurological failure, the primary reason for admission was the presence of another organ failure, but in the logistic regression model we found that neurological failure was an important predictor of mortality. This association needs to be clarified by other studies.

Sepsis was the other most important predictor of survival. These results were in correlation with the literature [1,2,5,6,9]. The probability of death in the presence of sepsis was found to be 91%, and sepsis was also shown to be a good predictor of death (Table V).

The predictive accuracy of the statistical method was tested and given in Table VI. Hosmer-Lemeshow H statistics yielded a p value of 0.056, indicating a significant predictive ability.

As a result of this retrospective study we have found that sepsis, neurological, cardiovascular and pulmonary failures are good predictors of mortality in our MICU when considered separately (these are sited in descending order of importance with the remaining OSF's being insignificant as predictors). This model of prediction of death among ICU patients seems to be simple in comparison to models derived from other studies [4-6,15] and may, thus, yield valuable information for physicians and families. Other prospective studies may yield more information as to the validity of use of our model in MICU patients' outcome.

Table III. Odds ratios in decreasing order, associated with organ failures and presence of sepsis (The ratio of "nonsurvivor to survivor ratio in the group with organ failure" to "nonsurvivor to survivor ratio in the group without organ system failure")

Organ system failure	Odds ratio
Pulmonary	22.51
Neurological	17.16
Sepsis	12.32
Cardiovascular	7.70
Hematological	3.05
Hepatic	2.00
Gastrointestinal	1.25
Renal	0.83
Endocrine	0.70

Table IV. Multivariate logistic function coefficients

Variable	Coefficient	P
Age	0.0047	NS
Sex	0.2235	NS
Initial diagnosis	- 0.1019	NS
Length of stay	-0.0453	NS
Chronic disease	-0.5541	NS
Number of OSF	0.7823	NS
Cardiovascular failure	1.9945	0.10
Pulmonary failure	1.9280	0.10
Renal failure	0.2575	NS
Neurologic failure	2.5752	0.05
Hematologic failure	0.4486	NS
GIS failure	0.3513	NS
Hepatic failure	1.3531	NS
Endocrine failure	-0.3731	NS
Sepsis	3.6546	0.01
Constant	-2.9826	0.01

NS = Not significant
The likelihood ratio statistics = 322.782 p = 0.001

Table V. Probabilities of death at various levels of significant predictor variables

Variable	Absent	Present
Sepsis Probability	0.2085	0.9106
Neurological failure Probability	0.2085	0.7729
Cardiovascular failure Probability	0.1782	0.6144
Pulmonary failure Probability	0.2090	0.6450

Table VI. Predicted and observed mortality in 499 patients

Predicted (%)	Observed No.	(%)
0 - 10	7/251	(3)
10 - 20	6/47	(13)
20 - 30	5/16	(31)
30 - 40	13/27	(48)
40 - 50	8/17	(47)
50 - 60	5/6	(83)
60 - 70	12/19	(63)
70 - 80	14/18	(78)
80 - 90	18/20	(90)
90 - 100	72/78	(92)
Hosmer - Lemeshow H statistic = 28.22 p = 0.056		

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