

Short- and Long-Term Survival of Nonsurgical Intensive Care Patients and its Relation to Diagnosis, Severity of Disease, Age and Comorbidities

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Abstract: *Objective:* To identify variables associated with mortality in the ICU and 1 year following discharge. *Design:* Prospective observational cohort study. *Setting:* ICU of a tertiary care center and university hospital. *Patients:* A total of 3,119 medical and neurological intensive care patients. *Measurements and Main Results:* Pre-admission health status was quantified by the sum of risk factors and chronic diseases. Severity of the acute disease was estimated by counting the number of organ dysfunctions and the Acute Physiology Score. Concerning the primarily affected organ system, ICU mortality was highest in hematological diseases (63%) and 1-year mortality was 82%. Lowest death rates were observed with metabolic (ICU 4%, 1-yr 18%) and psychiatric diagnoses (ICU 5%, 1-yr 13%). Greater severity of illness with the need for mechanical life support was associated with decreased 1-year survival. In the respiratory and in renal diseases, the artificial support of the primarily affected organ system incurred an ICU mortality equaling the average (23%) or below (14%) that of the whole ICU population. Pre-admission health status increased the probability of developing multiple organ failure and worsened outcome 1 year after discharge in non-cardiovascular patients. Age showed a weak correlation with chronic diseases and severity of the acute illness and was related to long-term, but not short-term survival. *Conclusions:* The most important risk factors associated with short- and long-term mortality in non-surgical intensive care patients are disease severity and the primarily affected organ system that necessitates admission. The artificial support of this organ system can improve only short-term outcome.

Keywords: Intensive care, outcome prediction, severity of illness, multiple organ failure, acute physiology score, age, elderly, comorbidities, mortality.

INTRODUCTION

The clinical management of intensive care patients includes diagnosis and treatment of acute, life-threatening illnesses and the restoration to previous health and quality of life. This must often be done in the context of uncertainty about the long-term benefits. As the age of the critically ill increases steadily [1], intensive care patients face an increased risk of developing multiple organ failure and death [2]. Today's means of artificial life support make it possible to keep patients with a hopeless prognosis alive for weeks and patients who are discharged from hospital often are severely disabled and have no chance for long-term survival [3]. It is important for ICU physicians and nurses to avoid prolonged suffering on the part of patients and their families in this situation. In addition, intensive care is costly, and optimal allocation of the limited resources available should be considered. An objective estimate of patient risk for mortality can provide efficient, and avoid useless intensive therapy; the basis for this could be one-year survival rates.

In this context, short-term (ICU and hospital) mortality is still a leading endpoint in clinical research. However, intensive care survivors may suffer from serious sequelae and their life expectancy is also of great socio-political interest [4]. It is recommended that ICU trials include a survival follow-up to at least 6 months [5]. The main

prognostic factors of survival are age, health status prior to admission, diagnostic category and severity of the acute disease [6-8]. Patients who are still alive 2 years after ICU admission reach a life expectancy similar to the general population [9].

Most studies on outcome of intensive care have been performed in mixed populations of surgical and medical patients [10-12]. The lack of homogeneity can be tempered with stratification according to diagnosis, but this procedure is handicapped by diminished sample size of the subgroups [13]. We therefore evaluated a large sample of nonsurgical adults admitted to the intensive care unit with internal-medical or neurologic emergencies and identified risk factors associated with short- and long-term mortality.

MATERIALS AND METHODS

Our medical ICU is a 9-bed unit serving a 1,600-bed university hospital with a catchment area population of 1.6 million. During an eight-year period, from 1/1992 to 1/2000, 3,119 consecutive patients were studied. All data were collected by a full-time critical care specialist (P.K.). The data were retrieved within 48 hours after admission from the patient's chart and entered into a notebook computer directly at the bedside. For measuring disease severity, only the first admission was taken into account. As in-hospital measurements described are routine for intensive care patients, special approval by the Human Subjects Committee was not deemed necessary. For data obtained from patients or surrogates after discharge from hospital, informed consent was given.

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According to the primarily affected organ system necessitating treatment in the ICU, patients were assigned to one of 11 diagnostic categories (Table 1). For each organ system, major disease categories were identified as the first link in the pathophysiologic chain leading to the life-threatening situation. At least one specific diagnosis was made for each patient.

Pre-admission chronic health status was assessed from medical history and clinical assessment. The severity of the comorbid condition was quantified by the sum of risk factors and chronic diseases such as coronary heart disease, cardiomyopathy, chronic pulmonary disease, liver cirrhosis, chronic renal failure, cerebrovascular disease, malignancy, immunodeficient status, immunosuppression and others (Table 1).

The most frequent risk factors are summarized in Table 2. Hypertension and diabetes mellitus were diagnosed according to WHO guidelines [14,15] or use of antihypertensive or antidiabetic drugs. Hyperlipidemia was defined as total cholesterol >220 mg/dl (5.7 mmol/l) and/or HDL cholesterol <35 mg/dl (0.9 mmol/l) or when subjects were

receiving lipid regulating drugs [16]. Patients were counted as smokers if they reported smoking at least one cigarette a day provided that they had not quit smoking > 1 year before [17,18]. Alcoholics were defined as patients with a daily alcohol consumption of at least 50 g ethanol during the last 2 years or longer. Information on alcohol consumption was obtained from the patient if possible, or otherwise from a close relative. Weight and height were measured in all ventilated patients (51% of the study population); in 49% information was provided through verbal communication with the patient or a proxy. Obesity was defined as a body mass index (BMI) equal to or greater than 30kg/m² [19]. Malnutrition was defined as a BMI under the 15th percentile [20] or a weight loss of more than 10% within 2 months before hospitalization in the absence of diuretic medication and/or a serum albumin concentration of less than 3.4 g/dl [21] in the absence of liver cirrhosis and nephrotic syndrome. Immobilization describes patients unable to walk on their own within a period of > 30 days [22] before admission to the ICU. Patients were characterized as elderly if they were 75 years or older.

Table 1. Patient Characteristics upon Admission

	n (%)	Age median (Lower/upper quartile)	Elderly (%)	Male (%)	Chron. health status median (Lower/upper quartile)	Ventilated (%)	CPR (%)
TOTAL	3119 (100)	64 (50/74)	22	56	4 (3/7)	51	14
Cardiovascular	1378 (44)	69 (59/76)	29	57	5 (3/7)	44	23
Metabolic	457 (15)	49 (31/66)	13	47	3 (2/5)	42	2
Gastrointestinal	350 (11)	57 (46/68)	11	63	4 (3/6)	36	2
Neurological	307 (10)	61 (46/72)	21	53	4 (3/7)	84	10
Respiratory	288 (9)	67 (53/77)	35	57	5 (4/8)	76	16
Systemic	135 (4)	57 (37/68)	10	54	4 (2/7)	78	5
Renal diseases	99 (3)	65 (54/73)	16	47	6 (4/7)	35	7
Hematological	51 (2)	49 (34/62)	6	57	3 (2/5)	63	4
Trauma	28 (1)	53 (36/65)	18	61	2 (1/5)	71	29
Psychiatric	18 (0.6)	44 (35/54)	0	67	2 (1/3)	33	11
Dermatologic	8 (0.4)	63 (50/70)	12	25	3 (2/5)	25	0
<i>p-value</i>		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
ICU survivors	2403 (77)	63 (47/73)	19	55	4 (2/6)	38	9
ICU non-survivors	716 (23)	69 (56/77)	32	58	6 (4/8)	96	29
<i>p-value</i>		< 0.01	< 0.01	<i>n.s.</i>	< 0.01	< 0.01	< 0.01
Hospital survivors	2024 (66)	61 (46/72)	17	55	4 (2/6)	34	7
Non-survivors	1059 (34)	69 (56/77)	33	56	6 (3/8)	85	27
<i>p-value</i>		< 0.01	< 0.01	<i>n.s.</i>	< 0.01	< 0.01	< 0.01
One-year survivors	1551 (55)	59 (43/71)	15	56	4 (2/6)	32	7
Non-survivors	1288 (45)	70 (54/76)	33	56	6 (3/7)	77	24
<i>p-value</i>		< 0.01	< 0.01	<i>n.s.</i>	< 0.01	< 0.01	< 0.01

Elderly: age of 75 years or older

Chronic health status: sum of risk factors and chronic organ diseases

CPR: Cardiopulmonary resuscitation before admission to the ICU

Non-survivors: cumulative data (i.e. hospital non-survivors include ICU non-survivors)

Table 2. Risk Factors for Medical Diseases

Risk Factors	Hypertension	Hyperlipidaemia	Smoking	Diabetes	Alcoholism	Obesity	Malnutrition	Immobilization
TOTAL	41	27	27	24	15	15	5	1
Cardiovascular	58	40	28	29	1	16	2	2
Metabolic	24	15	25	26	23	10	6	0.5
Gastrointestinal	24	16	27	15	50	13	5	0.2
Neurological	61	23	18	18	14	11	4	0.3
Respiratory	35	16	36	16	14	17	11	1
Systemic	33	18	26	15	13	17	7	4
Renal diseases	70	10	22	33	2	16	0	1
Hematological	14	24	18	2	0	14	12	0
Trauma	29	14	25	11	36	4	4	1
Psychiatric	5	17	17	17	33	11	5	0
Dermatologic	0	0	37	12	25	62	0	0

Data are given in percent.

Severity of the acute disease on the day of admission was estimated by counting the number of organ dysfunctions using a modification of the ODIN model [23]. Patients were considered to have multiple organ failure (MOF) if they developed failure of at least 3 organ systems. This definition is in contrast to conventional practice (MOF = failure of at least 2 vital organ systems), but in our experience with the clinical course of ICU patients, uncomplicated heart failure is often combined with pulmonary congestion and uncomplicated poisoning can be associated with temporary loss of consciousness. As treatment of the underlying disease normalizes the secondary organ dysfunction without additional therapeutic measures, it appeared that the dysfunction of a third organ system in the pathophysiologic chain of the acute disease would be more relevant with respect to outcome. To further quantify severity, we determined the Acute Physiology Score (APS) on admission [24]. APS is a part of the APACHE-III score (APACHE = Acute Physiology And Chronic Health Evaluation) where points are given for 16 physiologic variables (vital signs and laboratory abnormalities). Greater deviations from normal result in a higher score.

To minimize distress to the patient's next of kin, data relating to mortality were collected from the hospital information system or the patient's general practitioner. One year after discharge from hospital, an attempt was made to contact all survivors by phone. If this attempt failed twice, the patient's nearest relative was contacted. If this also failed, we consulted the communal registry. This procedure failed in 280 cases and we accepted that those patients were lost to follow up.

Statistical Analysis - Univariate Procedures

The chi-square test was used to compare qualitative variables such as gender, age groups, diagnostic categories, history of pre-admission CPR, the presence of ventilation, MOF and mortality. Distribution fitting of metric data was achieved with the Kolmogorov-Smirnov test. Since the data

on age, chronic health status, number of organ dysfunctions, and APA scores were not normally distributed, they were summarized using the median and the interquartile range (25th to 75th percentile). Statistical comparison was done with the Kruskal-Wallis test. Differences at a level of $p < 0.05$ were considered significant. Correlation between not normally distributed numeric data was estimated by the Spearman rank test.

Statistical Analysis – Multivariate Procedures

Variables, that had $p < 0.05$ by univariate testing were used in a logistic multinomial regression model to identify those significantly associated with mortality. Vital status (alive or death) within 4 different time periods (time in ICU, time in hospital after ICU discharge, time at home after discharge from hospital and time 1 year after discharge from hospital) was used as the dependent parameter. The following influencing categorial variables were entered into the model: For disease severity the presence of MOF or not in the ICU, for age to be elderly (≥ 75 years) or not, and the diagnostic category. Chronic health status as a numeric variable was used as covariate. To test the contribution of each effect to the model, the -2 log-likelihood was computed for the reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis was that all parameters of that effect are zero.

RESULTS

Within the 11 diagnostic categories following major disease categories were identified: In cardiovascular emergencies, the most frequent major disease category was acute coronary syndrome ($n = 660 / 48\%$) followed by acute deterioration of chronic heart failure ($n = 270 / 20\%$), pulmonary embolism ($n = 173 / 13\%$) and severe hypertension ($n = 116 / 8\%$). In metabolic disorders, poisoning was the leading cause ($n = 290 / 63\%$) followed by diabetic coma ($n = 83 /$

18%) and fluid/electrolyte disturbances (n = 70 / 15%). Predominant gastrointestinal emergencies were hemorrhage (n = 144 / 41%) and acute pancreatitis (n = 122 / 35%). In 35 patients (10%), liver failure was identified as the primary disease. Life-threatening neurologic diseases consisted of intracranial bleeding (n = 114 / 37%), cerebral infarction (n = 70 / 23%), meningitis/encephalitis (n = 62 / 20%), seizures (n = 38 / 12%), myasthenia (n = 12 / 4%) and advanced CNS neoplasm (n = 11 / 4%). In acute respiratory failure, exacerbation of chronic bronchopulmonary disease was most frequent (n = 139 / 48%), followed by pneumonia (n = 59 / 20%) and upper airway obstruction (n = 51 / 18%). Sepsis was the leading cause of systemic disorders (n = 84 / 62%) and thrombotic thrombocytopenic purpura or hemolytic uremic syndrome was diagnosed in 19 cases (14%). Thirteen patients suffered from metastatic cancer (10%) and 12 from acute autoimmune diseases (9%) such as lupus erythematosus, Wegener's granulomatosis or Goodpasture's syndrome. The main renal diagnosis was exacerbation of chronic renal failure (n = 65 / 66%). Acute renal failure was found in 34 patients (34 %). In hematological emergencies, leukemia (80% following treatment) was the most frequent underlying disease of sepsis and multiple organ failure (n =

27 / 53 %), followed by lymphoma (n = 15 / 29 %) and hemolytic crisis (n = 9 / 18%). Nonoperative trauma patients suffered from near drowning (n = 7 / 25 %), strangulation (n = 6 / 21.5 %), severe contusion (n = 6 / 21.5 %), head trauma (n = 5 / 18 %) and electrical injury (n = 4 / 14 %). In psychiatric patients we observed catatonic stupor in 45%, delirium in 34% and acute psychosis in 11%. Lyell's syndrome was the main diagnosis in dermatological diseases.

We found significant differences between the diagnostic categories as well as between survivors and non-survivors. Table 1 shows that patients with cardiovascular, neurological, respiratory and renal diseases were older and had more risk factors and chronic diseases than the patients in the other groups. Age was lower in metabolic, hematological and psychiatric emergencies associated with a better chronic health status. The overall correlation between age and the sum of risk factors and chronic diseases was significant but weak at 0.44. Differences were also present when mortality was taken into account. The median age of survivors and the proportion of elderly persons were significantly lower when compared to non-survivors. Spearman rank correlation coefficients between age and sum of risk factors and chronic diseases were 0.48 for ICU survivors, 0.25 for ICU deaths,

Table 3. Severity of Disease and Outcome Data

	Admission from other hospital	MOF (%)	ODIN median lower/upper quart	APS median lower/upper quart	Deaths in ICU (%)	Deaths in hospital (%)	Mortality after 1 year (%)
TOTAL	27 %	64	3 (2/4)	56 (33/79)	23	34	45
Cardiovascular	21 %	51	3 (1/4)	47 (26/74)	22	32	44
Metabolic	22 %	64	3 (2/4)	52 (33/68)	4	9	18
Gastrointestinal	29 %	63	3 (2/5)	53 (29/81)	25	37	46
Neurological	50 %	83	4 (3/5)	70 (53/85)	40	58	67
Respiratory	24 %	78	4 (3/5)	63 (47/80)	23	38	53
Systemic	33 %	93	5 (4/6)	74 (50/97)	44	57	64
Renal diseases	47 %	85	4 (3/5)	62 (50/81)	14	33	52
Hematological	14 %	88	6 (4/7)	93 (70/116)	63	76	82
Trauma	18 %	75	3 (2/5)	62 (50/82)	32	46	61
Psychiatric	67 %	78	3 (3/4)	56 (40/66)	5	11	13
Dermatologic	100 %	87	4 (3/5)	47 (33/84)	25	37	50
<i>p-value</i>	< 0.01	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
ICU survivors	27 %	53	3 (1/4)	47 (28/66)	0	0	0
ICU non-survivors	25 %	98	5 (4/6)	89 (72/108)	100	100	100
<i>p-value</i>	<i>n.s.</i>	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Hospital survivors	27 %	47	2 (1/4)	42 (26/62)	0	0	0
Non-survivors	26 %	95	5 (4/6)	82 (65/100)	67	100	100
<i>p-value</i>	<i>n.s.</i>	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
One-year survivors	27 %	45	2 (1/4)	40 (25/61)	0	0	0
Non-survivors	26 %	89	4 (3/5)	78 (49/93)	56	82	100
<i>p-value</i>	<i>n.s.</i>	<0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

MOF = multiple organ failure

ODIN = sum of organ failures within the first 24 hours after admission

APS = acute physiology score

Non-survivors: cumulative data (i.e. hospital non-survivors include ICU non-survivors)

0.50 for hospital survivors, 0.22 for hospital deaths, 0.50 for 1-year survivors and 0.22 for 1-year non-survivors.

Males more frequently had gastrointestinal and psychiatric emergencies and nonoperative trauma. Regarding mortality, there were no statistically significant differences between females and males.

Readmissions represented 2% of the whole study population and their mortality rates were not different when compared to first admission (36% vs. 37 % for hospital mortality and 48% vs. 45 % for 1-year mortality).

The proportion of ventilated patients was highest in neurological diseases, followed by systemic and respiratory diagnoses. In hematological diseases and in non-operative trauma, we also observed an increased need for respiratory support. A low percentage of ventilated patients was found in dermatological, psychiatric, renal and gastrointestinal emergencies. Differences were highly significant between survivors and non-survivors. Multivariate subgroup analysis of ventilated patients showed that severity of the disease as measured by APA score has the strongest impact on survival, followed by age, disease category and the number of chronic diseases. ICU mortality was 46%, significantly higher when compared to the group of patients not receiving mechanical respiratory support (2%). One year after admission to the ICU, we observed a survival rate of 33% in ventilated patients and 78% in non-ventilated patients ($p < 0.0001$). When artificial support of the primarily affected organ system is considered, the ICU mortality of ventilated pulmonary patients decreased to 31% and the 1-year survival rate increased to 40%. Patients with renal diseases as the primary reason of ICU admission had an ICU death rate of 14% under extracorporeal elimination procedures, which is clearly below the ICU mortality of the total cohort of all ICU patients (23%). One-year survival was 51%, slightly lower when compared to the total ICU cohort (55%).

Pre-admission cardiopulmonary resuscitation was often performed in cardiovascular, respiratory and traumatological emergencies, was not necessary in dermatologic diseases and seldom done for metabolic, gastrointestinal and hemato-

logical problems (Table 1). In the subgroup of resuscitated patients, high APA scores were associated with a low probability of survival. Age and chronic health status had a weaker, but significant influence on outcome. The disease category had no impact on survival.

The proportion of patients transferred from outlying hospitals to the ICU was high in dermatologic, psychiatric, neurological and renal emergencies; there were no significant differences between survivors and non-survivors (Table 3).

Severity of illness on the day of admission as estimated by the presence of MOF, number of organ failures (ODIN) and APS was significantly enhanced in hematological, neurological and systemic diseases including sepsis. The levels were substantially lower in the cardiovascular, metabolic and gastrointestinal categories (Table 3). Survivors and non-survivors showed statistically significant group differences.

Regression analysis revealed a weak positive overall correlation between age and APS ($r = 0.16$, R-squared = 2.6 %, $p < 0.01$). When stratified according to diagnostic categories, correlations were higher in metabolic and systemic diseases ($r = 0.37$, R-squared = 14 % and 13 %, $p < 0.01$). No correlations were found in respiratory, gastrointestinal and hematological emergencies. The extent of the comorbid condition as quantified by the sum of risk factors and chronic diseases was significantly related to severity of illness (regression with APS: $r = 0.25$, R-squared 6%, $p < 0.01$ and regression with ODIN: $r = 0.79$, R-squared 62%, $p < 0.01$). Fig. (1) shows that the frequency of multiple organ failure increases with the sum of risk factors and chronic diseases ($p < 0.01$ by chi-square test).

Short- and long-term mortality was highest in hematological diseases, followed by systemic and neurological emergencies. Death rates were lowest in the metabolic and psychiatric diagnostic organ systems.

As a point of interest, the differences between cumulative ICU and 1-year death rates (= ICU survivors who did not survive 1 year after discharge from ICU) were highest in renal, respiratory and neurological diseases as well as in

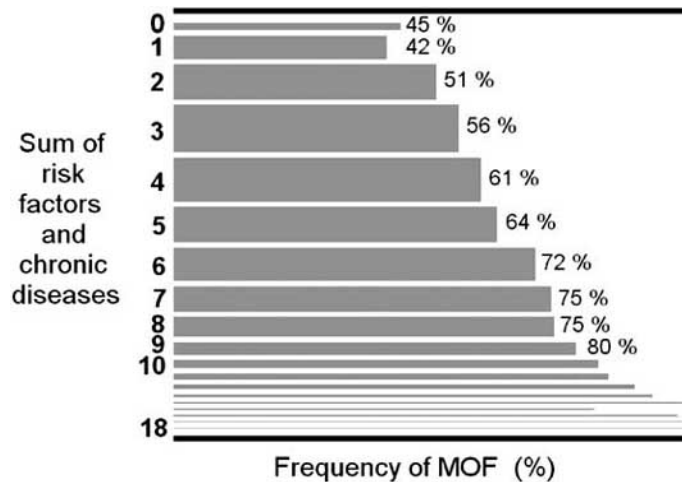


Fig. (1). Relative frequency of multiple organ failure (MOF) in relation to chronic health status as estimated by the sum of risk factors and chronic diseases. The length of the bars is proportional to the percentage of MOF in each chronic health category (full length of the x-axis = 100%). The width of the bars represents the number of patients as a percent of the whole study population (full length of the y-axis = 100%).

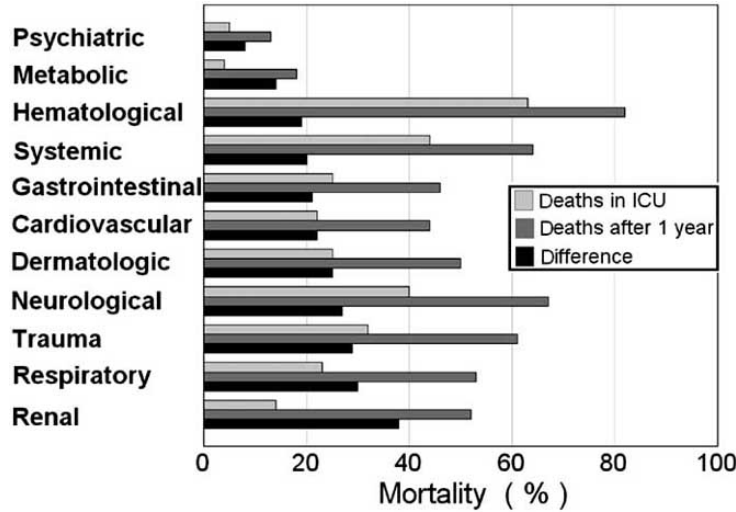


Fig. (2). Cumulative death rates in relation to diagnostic organ systems in intensive care patients. The black bars as the differences between 1-year and ICU death rates represent ICU survivors who did not survive 1 year after discharge from ICU.

nonoperative trauma (Fig. 2). In contrast to this finding, 80% or more of patients discharged from ICU after systemic, hematological, metabolic and psychiatric emergencies were still alive after 1 year.

Age was strongly linked to outcome regarding long- and short-term survival (Table 1). The most pronounced difference was observed in one-year survivors who were significantly younger (median= 59 years; $p < 0.01$ by Kruskal-Wallis test). The proportion of elderly patients with fatal outcomes was significantly higher than younger persons: ICU deaths 35% vs. 22%, for hospital-deaths 18% vs. 10% and for 1-year-deaths 12% vs. 7%. Conversely, the elderly formed a minority among the 1-year survivors: 34 vs. 61%, ($p < 0.01$, chi-square test).

Survival was also partially influenced by the comorbid condition: the median (interquartile range) of the sum of risk

factors and chronic diseases was 6 (4) in ICU deaths, 5 (3) in hospital deaths and 6 (4) in 1-year deaths.

One-year survivors had significantly fewer comorbidities than the other outcome groups: 4 (4); $p < 0.01$. As Fig. (3) shows, 1-year survival decreases as comorbidities increase ($p < 0.01$). On the other hand, the proportion of ICU deaths tends to be associated with an increasing sum of risk factors and chronic diseases.

Severity of illness on the day of admission was a further factor we found to be significantly associated with outcome: the number of organ failures (ODIN) was highest in ICU deaths (median = 5, interquartile-range = 2), high in hospital deaths (4, 2), lower in 1-year deaths (3, 2) and lowest in 1-year survivors (2, 2; $p < 0.01$). A similar relationship was found for the APS score. Fig. (4) displays the distribution of the APS scores grouped by outcome. The median APS score

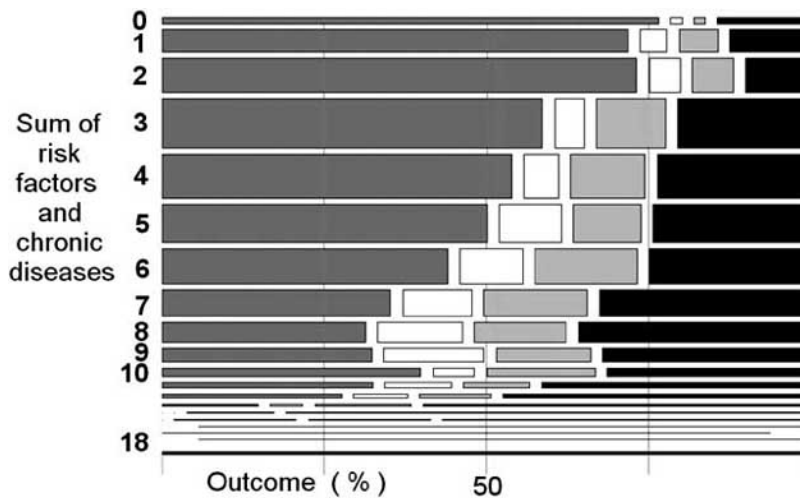


Fig. (3). The mosaic chart displays the relative frequency of 4 outcome categories in relation to chronic health status as estimated by the sum of risk factors and chronic diseases: Dark grey bars = 1-year survivors, white bars = 1-year deaths, light-grey bars = hospital deaths and black bars = ICU deaths. The length of the bars is proportional to the percentage of the outcome categories in each chronic health category (full length of the x-axis = 100%). The width of the bars represents the number of patients as a percent of the whole study population (full length of the y-axis = 100%).

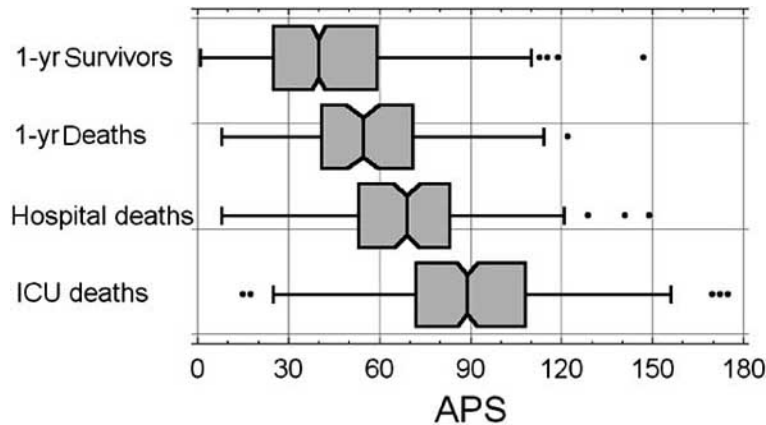


Fig. (4). Acute Physiology Scores (APS) in ICU patients grouped by outcome are displayed by box-and-whisker plots. The plots divide data in 4 areas of equal frequency. The box encloses the middle 50%. The median is drawn as a vertical line inside the box (median notch). Two horizontal lines extending from each end of the box represent data distribution from the first and third quartile to the smallest and largest data points within 1.5 interquartile ranges. Far outliers (data points more than 3 interquartile ranges below the first or above the third quartile) are displayed as black points.

for ICU deaths was 89 (interquartile range 36), for hospital deaths 69 (30), for 1-year deaths 54 (30) and for 1-year survivors 40 (34).

Table 4 shows the multivariate analysis with logistic multinomial regression, in which mortality was significantly associated with disease severity, disease category, chronic health status and age. Overall, 65% of the cases are classified correctly.

DISCUSSION

Scoring systems are used in many ICUs all over the world to estimate severity of illness and to predict mortality. We used the newer version of the APACHE score (APACHE-III), because it demonstrated better calibration than the older version [24]. To decrease the risk of classification bias by inter-observer variability [25], the scores were calculated by a single investigator.

In a population of 3,119 nonsurgical intensive care patients we found that disease severity and the primarily affected diagnostic organ system had the strongest impact on outcome. Furthermore, increased severity of illness in combination with artificial respiratory support was associated with high death rates. Severe comorbidity increases the probability of multiple organ failure and worsens outcome 1 year after discharge from hospital in non-cardiovascular

patients. Age showed a weak correlation with chronic diseases and severity of the acute illness and was related to long-term, but not short-term survival.

Previous studies have indicated that overall ICU mortality depends largely on the medical disease precipitating admission. Potgieter *et al.* [7] reported a mortality of 42% in patients with ARDS and sepsis which is similar to the 44% ICU mortality of systemic diseases in our study. Diagnosis also has an important impact on long-term survival after intensive care. If trauma victims survive their initial injuries, their short- and long-term outlook is good [26], whereas patients admitted with renal failure or who develop renal failure in the intensive care unit have much poorer survival [27]. Our data were comparable for renal diseases: in spite of severe acute illness, artificial extra-corporeal elimination procedures made it possible to keep short-term mortality to the average for the whole ICU population. Nevertheless, in association with a greater number of chronic diseases, mortality after discharge from ICU was the highest of all diagnostic categories. Metnitz *et al.* [28] found in a cohort of mixed medical and surgical patients a significantly higher hospital mortality under renal replacement therapy when compared with control ICU patients matched for age and severity of illness. In the present study we stratified patients by disease categories and could confirm these findings for non-renal diseases as the reason for ICU admission. Patients with renal diseases as the primary reason of ICU admission

Table 4. Multivariate Analysis with Logistic Multinomial Regression between Mortality and other Variables in 2839 Patients Admitted to the ICU

Effect	-2 Log-Likelihood of Reduced Model	Chi-Square	df	p-value
Disease severity	2378	709	6	< 0.0001
Disease category	1959	290	30	< 0.0001
Chronic health status	1804	136	3	< 0.0001
Age	1726	57	3	< 0.0001
Constant	1668	0	0	

The chi-square statistic is the difference in Log likelihoods between the final model and a reduced model.

had an ICU death rate of 14% under extracorporeal elimination procedures, which is clearly below the ICU mortality of the total cohort of all medical ICU patients (23%). For trauma victims, we were unable to confirm the observations of a good long-term outlook after discharge from hospital. This could be due to the limited number of cases and a high portion of near-drowned and strangulated patients who were neurologically compromised.

In another study, for patients with hematological malignancies, ICU and hospital mortality rates were found to be 43% and 57% respectively, and among survivors, 46% were not alive after 1 year [29]. However, the data from the present investigation demonstrated mortality rates that were clearly higher and were the highest within the whole ICU study population. Similarly low survival rates were confirmed by recent studies [30, 31]. This may be explained by the increasing number of bone marrow transplant patients, who represent a subset of patients with an extraordinary risk of death [32]. The positive aspect of our observations was that 81% of patients with hematological diseases surviving and being discharged from the hospital also survived 1 year. Such an increased short-time mortality followed by a decreased 1-year death rate for ICU survivors was also found in patients with systemic diseases. In contrast, neurological cases with both high short-term and long-term death rates included ICU survivors with an increased 1-year mortality. In this context, it must be emphasized that the neurological patients in this study represent a negatively selected subgroup with acute respiratory failure requiring mechanical ventilation in 84%. This explains the high ICU death rate of 40%, which is similar to the 46% in the study of Bleck *et al.* in the subgroup of patients admitted to the ICU with primary neurologic problems [33].

Advanced age and comorbidities have been shown to increase mortality following intensive care [11,34]. These findings are consistent with our data. However, age and chronic health status showed a weaker correlation in non-survivors when compared to survivors when the whole ICU study population was taken into account. This discrepancy stems from the fact that in the large group of patients with cardiovascular diseases, mortality was relatively low despite advanced age and an increased number of chronic diseases. In contrast, most of the hematological patients were very young and had few comorbidities, but an extraordinary death rate.

Severity of illness on admission to the ICU influences short-term mortality, but has been shown to be less good at predicting long-term outcome in a mixed population of medical and surgical patients [11]. In a recent study [35] longterm prognosis dependet chiefly on the functional status, whereas initial disease severity did not influence mortality. However, our study identified disease categories with increased severity of illness upon ICU admission such as neurological, respiratory, systemic, renal and hematologic diseases and non-operative trauma. Common to all is a high proportion of artificial mechanical life support procedures during the ICU stay, which is associated with decreased 1-year survival. Boumendil *et al.* [36] found that the need for mechanical ventilation in patients aged 80 years and over is a significant prognostic factor of death. However, in the

respiratory disease category (artificial ventilation when the lung is the primarily affected organ system) and in renal diseases as well (extracorporeal elimination procedures to support the kidneys as primarily affected organ system) ICU mortality was below the whole ICU population, despite a high percentage of MOF and high ODIN and APS scores. Therefore, from the prognostic point of view, intensive care management ist justified in elderly patients fulfilling the criteria as described above. In elderly patients requiring mechanical ventilation or hemodialysis/hemofiltration as a consequence of MOF in other disease categories than respiratory or renal, the benefit of ICU admission remains unclear.

Only a minority of patients (31%) were discharged alive from hospital after successful cardiopulmonary resuscitation. In the United States, more than 60% of these victims die within 24h [37]. This is in accordance with previously published data from Pesau *et al.* [38], who reported a survival rate of 23%. Patients aged >70 years exhibited a mortality not significantly different from their younger counterparts. However, we saw an increased death rate in resuscitated elderly patients. In addition, in recent work, coronary heart disease was diagnosed in 72% [39]. This would explain the high incidence of CPR in cardiovascular patients.

We acknowledge that the study has a number of limitations. Since this was a single-center study, we cannot exclude possible selection biases concerning differences in standards of care such as admission/discharge policies including triage decisions, do-not-resuscitate orders and variations in treatment practices when compared to other intensive care units. In addition, the assessment of quality of life after discharge from hospital remains another important measure of long-term outcome [11,40,41].

CONCLUSIONS

The most important risk factors associated with short- and long-term mortality in nonsurgical intensive care patients are disease severity and the primarily affected organ system that necessitates admission. The artificial support of this organ system can improve only short-term outcome.

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