Rui Moreno
Dinis Reis Miranda
Ricardo Matos
Teresa Fevereiro

Mortality after discharge from intensive care: the impact of organ system failure and nursing workload use at discharge

Received: 4 December 2000
Final revision received: 21 March 2001
Accepted: 3 April 2001
Published online: 18 May 2001
© Springer-Verlag 2001

R. Moreno (✉) · R. Matos · T. Fevereiro
Unidade de Cuidados Intensivos
Polivalente,
Hospital de St. António dos Capuchos,
Alameda de Santo António dos Capuchos,
1150 Lisbon, Portugal
E-mail: r.moreno@mail.telepac.pt

D. R. Miranda
Health Services Research Unit,
University Hospital Groningen,
Groningen, The Netherlands

Abstract *Objectives:* Mortality after ICU discharge accounts for approx. 20–30 % of deaths. We examined whether post-ICU discharge mortality is associated with the presence and severity of organ dysfunction/failure just before ICU discharge.

Patients and methods: The study used the database of the EURICUS-II study, with a total of 4621 patients, including 2958 discharged alive to the general wards (post-ICU mortality 8.6 %). Over a 4-month period we collected clinical and demographic characteristics, including the Simplified Acute Physiology Score (SAPS II), Nine Equivalents of Nursing Manpower Use Score, and Sequential Organ Failure Assessment (SOFA) score.

Results: Those who died in the hospital after ICU discharge had a higher SAPS II score, were more frequently nonoperative, admitted from the ward, and had stayed longer in the ICU. Their degree of organ dysfunction/failure was higher (admission, maximum, and delta SOFA scores). They required more nursing

workload resources while in the ICU. Both the amount of organ dysfunction/failure (especially cardiovascular, neurological, renal, and respiratory) and the amount of nursing workload that they required on the day before discharge were higher. The presence of residual CNS and renal dysfunction/failure were especially prognostic factors at ICU discharge. Multivariate analysis showed only predischarge organ dysfunction/failure to be important; thus the increased use of nursing workload resources before discharge probably reflects only the underlying organ dysfunction/failure.

Conclusions: It is better to delay the discharge of a patient with organ dysfunction/failure from the ICU, unless adequate monitoring and therapeutic resources are available in the ward.

Keywords ICU discharge status · Hospital mortality · Organ dysfunction/failure · Nursing workload · Sequential Organ Failure Assessment score · Simplified Acute Physiology Score II

Introduction

A significant number of critical ill patients die in the hospital after discharge from the intensive care unit (ICU). Data on this so-called occult mortality, well known since the 1980s, vary significantly between series. Examples include the GiViTI study with 26 % of deaths occurring after ICU discharge [1], the Portuguese study

(23 %) [2], the EURICUS-I study (31 %) [3], and the North Thames study (27 %) [4]. Several researchers have studied this problem, focusing mainly on factors outside the ICU [5], proposing inclusive new methods to deal with this problem [6]. Others have considered factors inside the ICU, such as the amount of nursing workload required by the patient in the 24 h before discharge to the ward [7].

We hypothesized that post-ICU discharge mortality is associated with the presence and severity of organ dysfunction/failure just before ICU discharge. The objective of this study is to test whether the presence, amount, and type of organ dysfunction/failure at discharge is related to postdischarge mortality, with the amount of nursing workload on the same period being a surrogate marker of this intrinsic patient severity.

Material and methods

The study used the database of the Foundation for Research on Intensive Care in Europe from the study EURICUS-II, which explored "the effect of harmonizing and standardizing the nursing tasks of the Intensive Care Units of the European Community" (BMH4-CT96-0817). Clinical and demographic characteristics, including the new Simplified Acute Physiology Score (SAPS II) [8], were collected for all admitted patients in the participating ICUs over a 4-month period. Patients were followed until hospital discharge, and their survival status was recorded. Readmissions were not analyzed.

Nursing workload was evaluated daily in all patients throughout the ICU stay using the Nine Equivalents of Nursing Manpower Use Score (NEMS) [9], and values were categorized according to the original description of Cullen et al. [10] as: class 1, 0–9 points; class 2, 10–19 points; and class 3, more than 19 points.

Organ dysfunction/failure was evaluated at ICU admission and after 24 h for two periods of 2 months each, using the Sequential Organ Failure Assessment (SOFA) score [11]. Derived variables based on the SOFA score were computed as previously described [12]. Total maximum SOFA score was calculated by adding the maximum scores for all the components of the system. The amount of organ dysfunction/failure appearing after ICU admission (Δ SOFA) was determined by subtracting the admission SOFA score from the total maximum SOFA. For purposes of analysis, organ failure was defined as a SOFA score of 3 points or more.

Patient forms were made anonymous by using a code number label. These consecutively numbered labels (country/ICU/patient) issued by the Coordination Center of the project allowed the survey of consecutiveness of patient entry compared with the official entry registration files of each ICU. Data were entered at ICU level on standardized forms. At the Coordination Center the data were entered in a computerized database. The forms were checked for accuracy and completeness, and those with missing data were returned to local coordinators for further inspection and possible completion. All persons involved had access to a detailed "operations manual" with the protocols and definitions to be used during the study, and they attended specially designed training sessions in each country. All variables were collected as raw data.

Student's *t* test was used to compare the means of normally distributed variables, the Mann-Whitney *U* test to compare the means of two nonnormally distributed variables, and the Kruskal-Wallis *H* test to compare the means of independent nonnormal variables.

A logistic regression equation was used to compute the odds ratios for the relative contribution of the six components of the SOFA score on the last ICU day and post-ICU mortality, with post-ICU outcome as dependent variable and the six components of the SOFA score as independent variables. The same statistical technique was used to evaluate the relative contribution of last-day NEMS and last-day SOFA on post-ICU outcome. In this case the dependent variable was post-ICU outcome and the independent variables were last-day NEMS, last-day SOFA, and the inter-

action between last-day NEMS and last-day SOFA. At a later stage the area of Europe was introduced as a categorical variable in the equation to determine whether significant variance remained after controlling for the effect of last-day SOFA and last-day NEMS.

Results are presented as mean $\pm$ standard deviation, with median and interquartile ranges given within parenthesis except when stated otherwise. Data analysis and statistics were performed using the Statistical Package for Social Sciences version 10.0.

Results

During the study period there were complete data on 4621 patients regarding the evaluated parameters. Of these, 621 (13.4%) died in the ICU. Of the 4000 patients discharged alive, 303 died before hospital discharge (32.8% of deaths), resulting in a global hospital mortality of 20.0%. From these 4000 patients discharged alive, 241 (6.0%) were discharged home, 2958 (74.0%) to the general ward, 362 (9.1%) to other ICU/intermediate care, and 357 (8.9%) to another hospital, and no information was available on 59 (1.5%).

The 2958 patients discharged alive from the ICU to the ward presented a post-ICU mortality of 8.6% (Table 1), with very wide variation between ICUs (Fig. 1). Compared with the patients discharged alive from the hospital, they had a higher SAPS II during the first 24 h in the ICU [40.7 ± 14.5 (40, 31–49) vs. 29.1 ± 15.2 points (28, 18–38); $p < 0.001$], were more frequently nonoperative (64.8% vs. 45.8%; $p < 0.001$), were admitted from the ward (37.5% vs. 19.0%), and had a longer stay in the ICU [8.8 ± 13.7 (3.1, 1.1–9.9) vs. 5.5 ± 9.0 days (2.4, 1.0–5.5); $p < 0.001$].

Patients who died after ICU discharge presented during the ICU stay a higher amount of organ dysfunction/failure. This is seen in a higher admission SOFA [4.14 ± 3.21 (4, 1–6) vs. 2.62 ± 2.73 (2, 0–4) points; $p < 0.001$], a higher mean daily SOFA [3.75 ± 2.51 (3.5, 1.95–5.5) vs. 2.30 ± 2.20 (1.9, 0.5–3.67) points; $p < 0.001$], and a higher maximum SOFA [6.61 ± 4.46 (6, 3–9.5) vs. 4.07 ± 3.82 (3, 1–6) points; $p < 0.001$]. Also, the amount of organ dysfunction/failure appearing while in the ICU (Δ SOFA) was significantly higher in nonsurvivors than in survivors [2.47 ± 3.18 (1, 0–4) vs. 1.45 ± 2.24 (0, 0–2) points; $p < 0.001$].

Nonsurvivors consumed more nursing workload resources while in the ICU than survivors, as indicated by a higher NEMS in the first 24 h in the ICU [25.6 ± 9.3 (25, 18–32.5) vs. 23.1 ± 8.9 (21, 18–27) points; $p < 0.001$], a higher mean NEMS during the ICU stay [23.6 ± 6.9 (24, 18–28.4) vs. 21.0 ± 6.7 (19.5, 17.3–25.8) points; $p < 0.001$], and a higher mean cumulative NEMS [209.6 ± 360.4 (65, 30–217) vs. 103 ± 171.6 (51, 27–102) points; $p < 0.001$].

To better understand the outcome after transfer from the ICU we studied in more detail the last 24 h in the ICU among patients discharged alive to the ward (Ta-

Table 1 Demographic characteristics, organ dysfunction/failure, recovery room, *LOS* length of stay in the ICU). Data is presented as mean $\pm$ standard deviation and nursing workload resources use of the patients discharged alive from the ICU to the general ward (*OR/RR* operative room/

Variable	Patients discharged to the ward [<i>n</i> = 2958]	Patients discharged alive from the ward [<i>n</i> = 2705 (91.4 %)]	Patients died in the ward [<i>n</i> = 253 (8.6 %)]	<i>p</i>
SAPS II	30.1 $\pm$ 14.9	29.1 $\pm$ 15.2	40.7 $\pm$ 14.7	< 0.001
Type of patient				< 0.001
Unscheduled surgery	668 (22.6 %)	619 (22.9 %)	49 (19.4 %)	
Scheduled surgery	867 (29.3 %)	827 (30.6 %)	40 (15.8 %)	
Nonoperative	1402 (47.4 %)	1238 (45.8 %)	164 (64.8 %)	
Unknown	21 (0.7 %)	21 (0.8 %)	0 (0.0 %)	
Location before ICU admission				< 0.001
OR/RR	1248 (42.3 %)	1807 (66.8 %)	71 (28.1 %)	
Emergency room	765 (25.9 %)	708 (26.2 %)	57 (22.5 %)	
Ward	608 (20.6 %)	513 (19.0 %)	95 (37.5 %)	
Other ICU/hospital	153 (5.2 %)	140 (5.2 %)	13 (5.1 %)	
Other	43 (1.5 %)	40 (1.5 %)	3 (1.2 %)	
Unknown	141 (4.8 %)	127 (4.7 %)	14 (5.5 %)	
SOFA score				
Admission	2.75 $\pm$ 2.81	2.62 $\pm$ 2.73	4.14 $\pm$ 3.21	< 0.001
Mean daily	2.43 $\pm$ 2.26	2.30 $\pm$ 2.20	3.75 $\pm$ 2.51	< 0.001
Maximum	4.29 $\pm$ 3.95	4.07 $\pm$ 3.82	6.61 $\pm$ 4.46	< 0.001
Δ SOFA	1.54 $\pm$ 2.35	1.45 $\pm$ 2.24	2.47 $\pm$ 3.18	< 0.001
NEMS				
First 24 h	23.4 $\pm$ 9.0	23.1 $\pm$ 8.9	35.6 $\pm$ 9.3	< 0.001
Mean daily	21.3 $\pm$ 6.8	21.0 $\pm$ 6.7	23.6 $\pm$ 6.9	< 0.001
Mean cumulative	112.5 $\pm$ 197.2	103 $\pm$ 171.6	209.6 $\pm$ 360.4	< 0.001
Length of ICU stay (days)	5.7 $\pm$ 9.4	5.5 $\pm$ 9.0	8.8 $\pm$ 13.7	< 0.001

ble 2). Globally, in the day before transfer, mean SOFA was significantly higher in those who subsequently died than in survivors [2.69 ± 2.41 (2, 0–4) vs. 1.60 ± 2.00 (1, 0–3) points; $p < 0.001$]. Mortality after discharge varied between 5.0% in patients discharged with a SOFA score of 0, to 19.4% in those discharged with a SOFA score higher than 5 (Fig. 2). There was also significant ($p < 0.01$) relationship between and the number of organ system failures present at discharge (Fig. 3), with mortality rates varying from 7.2% in patients discharged without any organ failure, to 20.5% in those discharged with 2 or more organ failures. There was a significant difference between survivors and nonsurvivors regarding four of the components of the SOFA system (cardiovascular, neurological, renal, and respiratory; Table 2); no difference was found regarding the hematological or hepatic components of the system.

The impact of the dysfunction/failure on post-ICU mortality was not the same for each of the six analyzed organ/systems. Using logistic regression with post-ICU mortality as dependent variable, the maximum impact was seen for central nervous system (odds ratio 1.74, 95% confidence interval 1.53–1.97) and renal systems (1.33, 1.17–1.52). No such association was observed for cardiovascular (1.15, 0.99–1.33), hematological (1.06,

0.86–1.31), hepatic (0.97, 0.74–1.28), or respiratory (1.11, 0.97–1.27) systems.

The mean NEMS on the last day in the ICU was 18.5 ± 6.7 (18, 15–21), significantly higher in nonsurvivors than in survivors [19.9 ± 6.9 (18, 18–25) vs. 18.4 ± 6.6 (18, 15–21) points; $p < 0.001$]. A significant ($p < 0.01$) relationship was determined between Cullen et al. [10] class on the last day in the ICU and post-ICU outcome (Fig. 4). This relationship was also affected by the number of organ system failures at discharge (Fig. 5).

Nonsurvivors presented a greater use than survivors in the last 24 h of intravenous medication and single vasoactive drugs. No significant differences were found for the other components of NEMS score (Table 2).

The contribution to post-ICU outcome of last-day NEMS was statistically nonsignificant (odds ratio for a one-point change in last-day NEMS 1.02, 95% confidence interval 0.99–1.05; $p = 0.220$) when last-day SOFA was taken simultaneously into account (1.30, 1.10–1.53; $p = 0.001$). No significant interaction was found between last-day NEMS and last-day SOFA (odds-ratio 0.99, 0.99–1.04; $p = 0.411$). After controlling for the above variables the European area remained a significant ($p < 0.001$) variable, implying that not all the

Fig. 1 Mortality in the intensive care unit and after discharge from the ICU in the sample under analysis. *Black bars* Mortality in the ICU; *gray bars* mortality after discharge from the ICU

variance in the postdischarge mortality is explained by last-day SOFA and last-day NEMS.

Discussion and conclusions

Current post-ICU discharge mortality rates are very high. The death of a patient after discharge from the

ICU, frequently after several days of investment, represents, among other things, a significant waste of costly resources. Moreover, such high mortality can become a dissatisfaction factor to the ICU staff, since hours and days of personal effort are often lost, in a matter of hours. Discharge of less stable patients from the ICU is therefore often delayed until sufficient stability is achieved before the transfer to the ward, where monitoring and therapeutic

Table 2 Organ dysfunction/failure and nursing workload resources use in the last 24 h in the ICU of the patients discharged alive from the ICU to the general ward ($n = 2958$)

Variable	Patients discharged to the ward	Patients discharged alive from the ward	Patients died in the ward	<i>p</i>
SOFA score				
Total	1.69 ± 2.06	1.60 ± 2.00	2.69 ± 2.41	< 0.001
Cardiovascular	0.27 ± 0.79	0.26 ± 0.77	0.41 ± 0.95	0.003
Neurological	0.21 ± 0.69	0.17 ± 0.61	0.62 ± 1.19	< 0.001
Hematological	0.24 ± 0.62	0.23 ± 0.61	0.28 ± 0.71	0.525
Hepatic	0.11 ± 0.46	0.11 ± 0.46	0.13 ± 0.48	0.362
Renal	0.28 ± 0.78	0.26 ± 0.75	0.50 ± 0.97	< 0.001
Respiratory	0.58 ± 0.91	0.56 ± 0.90	0.74 ± 0.98	0.002
NEMS score				
Total	18.5 ± 6.7	18.4 ± 6.6	19.9 ± 6.9	< 0.001
Basic monitoring	288 (96.0 %)	2613 (96.6 %)	245 (96.8 %)	0.841
Intravenous medication	2472 (83.6 %)	2245 (83.0 %)	227 (89.7 %)	0.006
Mechanical ventilatory support	388 (13.1 %)	346 (12.8 %)	42 (16.6 %)	0.086
Supplementary ventilatory care	1760 (59.5 %)	1601 (59.2 %)	159 (62.8 %)	0.257
Single vasoactive medication	348 (11.8 %)	303 (11.2 %)	45 (17.8 %)	0.002
Multiple vasoactive medication	75 (2.5 %)	68 (2.5 %)	7 (2.8 %)	0.807
Dialysis techniques	22 (0.7 %)	18 (0.7 %)	4 (1.6 %)	0.105
Specific interventions in the ICU	124 (4.2 %)	111 (4.1 %)	13 (5.1 %)	0.432
Specific interventions outside the ICU	93 (3.1 %)	89 (3.3 %)	4 (1.6 %)	0.136

Fig.2 Relationship between SOFA points during the last 24 h in the ICU and mortality after discharge. The number of patients in each group is: 0 points, 1289; 1 point, 370; 2 points, 476; 3 points, 299; 4 points, 203; 5 points, 141; > 5 points: 180

Fig.4 Relationship between Cullen class [10] on the last ICU day and post-ICU mortality. The number of patients in each class is: class 1, 276; class 2, 1881; class 3, 801

Fig.3 Number of organ system failures present at discharge and outcome after discharge. The number of patients in each group is: no organ failures: 2536, one organ failure, 378; two organ failures, 44

Fig.5 Relationship between Cullen class [10] on the last ICU day, the number of organ system failures (OSF) on the same period, and post-ICU mortality

tic resources are much less intense. This may explain the low effectiveness in the use of nursing workload resources in the majority of European ICUs [13], since ICUs are occupied with patients who may not no longer require intensive care. Some authors have therefore proposed mathematical methods for identifying patients with a lower risk of requiring life support on the next day, which could be used to confirm the physician's judgment in the decision to discharge [14]. However, these have not gained widespread support and are not used to investigate the major determinants of post-ICU mortality.

Recently Smith et al. [7] analyzed 238 patients discharged alive from the ICU to in-hospital wards. They found that high Therapeutic Intervention Scoring System (TISS) [15] levels on discharge from the ICU were associated with an increased risk of in-hospital mortality, with mortality rates ranging from 7.3 % in patients with a predischage TISS lower than 10, to 21.4 % in those with a predischage TISS greater than 19. The proposed method, based on predischage TISS is easy to implement and can be added to current determinants of the decision to discharge a patient (e.g., clinical, bed

policies, shortage of beds, national, and international recommendations) but has not been independently validated or compared with other – physiological – determinants of post-ICU mortality.

Our hypothesis was that a major determinant of the post-ICU mortality is the presence and severity of organ dysfunction/failure just before ICU discharge, and that this is principally responsible for the occurrence of these deaths.

We used a large multicenter, multinational database to study 4621 patients, including 2958 discharged alive to general wards, with a post-ICU mortality of 8.6%. Globally patients who died after discharge from the ICU had a higher SAPS II during the first 24 h in the ICU, were more frequently nonoperative, and had a longer stay in the ICU. During their ICU stay they had a higher rate of organ dysfunction/failure, as shown by a higher admission SOFA, a higher mean daily SOFA, a higher maximum SOFA, and a higher Δ SOFA. They also consumed more nursing workload resources while in the ICU.

Compared with the patients who survived hospital stay, they had a higher rate of organ dysfunction/failure on the last ICU day, especially of the cardiovascular, neurological, renal, and respiratory organ systems, using more nursing resources during the same period. However, in multivariate analysis only predischARGE organ dysfunction/failure seems important, which indicates that probably the associated intensity in the use of nursing workload resources before discharge reflects only the underlying organ dysfunction/failure.

The extent to which the death of patients discharged with an important residual degree of organ systems failure is due to the incapability of the ward to provide the care needed for their support remains to be analyzed. Also, a more detailed follow-up of the discharged patients should be the matter of further research, since only the sequential evaluation of the course of the organ dysfunction/failure and the evaluation of the degree of match between this physiological measure and the amount of nursing workload resources used in the patient can further clarify the situation. Other factors can also be important, such as differences in practices in different areas regarding the way in which families' decisions for their relatives to die home or in the hospital are made as well as as "do-not-resuscitate" orders. It should be noted also that the present study represents a post hoc analysis of a database assembled to test other research questions, and that some of the variables potentially important to explain the differences be missing from the study. This is especially important since differences in organizational cultures across Europe can have a significant impact in the way such problems are handled in different areas.

Our results suggest the need for (a) the careful analysis of the monitoring and therapeutic requirements of the patient before discharge from the ICU, in cases of organ dysfunction/failure is still present and supported; and (b) the provision of workload available in the new location that is needed to meet the identified requirements.

References

1. Apolone G, D'Amico R, Bertolini G, et al (1996) The performance of SAPS II in a cohort of patients admitted in 99 Italian ICUs: results from the GiViTL. *Intensive Care Med* 22: 1368–1378
2. Moreno R, Morais P (1997) Outcome prediction in intensive care: results of a prospective, multicentre, Portuguese study. *Intensive Care Med* 23: 177–186
3. Moreno R, Reis Miranda D, Fidler V, Van Schilfgaarde R (1998) Evaluation of two outcome predictors on an independent database. *Crit Care Med* 26: 50–61
4. Goldhill DR, Sumner A (1998) Outcome of intensive care patients in a group of British intensive care units. *Crit Care Med* 26: 1337–1345
5. Lawrence A, Havill JH (1999) An audit of deaths occurring in hospital after discharge from the intensive care unit. *Anaesth Intensive Care* 27: 185–189
6. Goldhill DR, Worthington L, Mulcahy A, et al (1999) The patient-at-risk team: identifying and managing seriously ill ward patients. *Anaesthesia* 54: 854–860
7. Smith L, Orts CM, O'Neil I, Batchelor AM, Gascoigne AD, Baudouin SV (1999) TISS and mortality after discharge from intensive care. *Intensive Care Med* 25: 1061–1065
8. Le Gall JR, Lemeshow S, Saulnier F (1993) A new Simplified Acute Physiology Score (SAPS II) based on a European/North American multicenter study. *JAMA* 270: 2957–2963
9. Reis Miranda D, Moreno R, Iapichino G (1997) Nine Equivalents of Nursing Manpower Use Score (NEMS). *Intensive Care Med* 23: 760–765
10. Cullen DJ, Civetta JM, Briggs BA, Ferrara LC (1974) Therapeutic intervention scoring system: a method for quantitative comparison of patient care. *Crit Care Med* 2: 57–60
11. Vincent J-L, Moreno R, Takala J, et al (1996) The SOFA (sepsis-related organ failure assessment) score to describe organ dysfunction/failure. *Intensive Care Med* 22: 707–710
12. Moreno R, Vincent J-L, Matos R, et al (1999) The use of maximum SOFA score to quantify organ dysfunction/failure in intensive care. Results of a prospective, multicentre study. *Intensive Care Med* 25: 686–696
13. Moreno R, Reis Miranda D (1998) Nursing staff in intensive care in Europe. The mismatch between planning and practice. *Chest* 113: 752–758
14. Zimmerman JE, Wagner DP, Draper EA, Knaus WA (1994) Improving intensive care unit discharge decisions: supplementary physician judgment with predictions of next day risk for life support. *Crit Care Med* 22: 1373–1384
15. Keene AR, Cullen DJ (1983) Therapeutic intervention scoring system: update 1983. *Crit Care Med* 11: 1–3

Copyright of Intensive Care Medicine is the property of Kluwer Academic Publishing / Academic and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.