Prognosis of critical surgical patients depending on the duration of stay in the ICU

Luciano Santana-Cabrera, Josefa Delia Martín-Santana¹, Rosa Lorenzo-Torrent, Hugo Rodríguez Pérez, Manuel Sánchez-Palacios, Juan Ramón Hernández Hernández²

ABSTRACT

Objective: To analyze the epidemiological and prognostic differences between critical surgical patients admitted to intensive care unit (ICU) according to length of stay in the ICU.

Materials and Methods: Retrospective observational study on patients with surgical pathology admitted to ICU of a tertiary hospital, during 7 years, with a stay ≥ 5 days. The variables analyzed were age, sex, Acute Physiology and Chronic Health Evaluation II (APACHE II), duration of stay, hospital and ICU mortality, original service, reason for admission, geographical place of residence, and the use of invasive techniques such as mechanical ventilation (MV), tracheotomy, and techniques of continuous renal replacement (CRR). Two groups were defined; one with intermediate stay, the one that exceeds the average of our population (> 5 days) and another with long stay patients (> 14 days). Readmissions were excluded. Firstly, the analysis of differential characteristics of patients was performed, this was according to the duration of their stay using either a contrast equal averages when the variable contrast between the two groups was quantitative or the Chi‑square test when the variable analyzed was qualitative. For both tests, the existence of significant differences between groups was considered when the significance level was less than 5%. And, secondly, a model forecast ICU survival of these patients, regardless of length of stay in ICU, using a binary logistic regression analysis was performed.

Results: Among the 540 patients analyzed, no significant differences were observed, depending on the length of stay in the ICU, except the need for invasive techniques such as MV or tracheotomy in those of longer stay (P = 0.000). However, ICU mortality was significantly higher for patients with intermediate stay (30 vs 17: 5%; P = 0.000), without observing differences in hospital mortality. ICU survival was influenced by age, APACHE II levels, admission to the ICU in a coma state, and the application of the three invasive techniques discussed.

Conclusion: Surgical patients who survive in the ICU, regardless of the length of their stay in it, have the same odds of hospital survival. Found as predictors of mortality in ICU APACHE II, age, admission in a coma state, and application of the three invasive techniques discussed.

Key Words: Critical illness, prognosis, stay, surgery

INTRODUCTION

For critical surgical patients, organ failure is the leading cause of admission to intensive care unit (ICU); it is what will determine the length of their stay and, of course, the prognosis.¹⁻⁴ This organ failure usually results from specific presurgical and postsurgical complications.
such as sepsis or systemic inflammatory response syndrome associated with underlying disease requiring surgery. These patients will need an organic carrier such as mechanical ventilation (MV), continuous renal replacement (CRR), or the use of catecholamines. The needs of these therapies for a long time will increase, as is logical, the ICU stay and its costs.\textsuperscript{5,6} It is, therefore, interesting to identify what factors influence or determine a more or less prolonged ICU stay in surgical patients, and to predict based on a number of factors, survival of these patients in ICU. On this basis, we establish the objective to analyze the epidemiological and prognostic differences between surgical patients admitted to intensive care unit (ICU) with intermediate stay (5–13 days) versus prolonged stay (> 14 days).

**MATERIALS AND METHODS**

Observational retrospective study of patients with surgical pathology admitted to the ICU of a tertiary hospital from January 2004 to December 2010, with ≥ 5 days stay. The number of patients with these characteristics was 540. The variables analyzed were age, sex, Acute Physiology and Chronic Health Evaluation II (APACHE II), duration of stay, hospital and ICU mortality, original service, reason for admission, geographical place of residence, and the use of invasive techniques such as MV, tracheotomy, and techniques of CRR. Two groups were defined, one with intermediate ICU stay, that is, all that exceeds our population average, which is > 5 days but less than 14 days, based on the average stay of the population studied is 5.6 days and the 75 percentile is in 5 days. Also, prolonged stay was defined as one that was ≥ 14 days, serving most of the studies cited in the literature review that addressed the analysis of prolonged stay.\textsuperscript{7} Readmissions were excluded to avoid multiple prognostic assessments of the same patient and, in the long-term prognostic study, the visitors for failure to keep track of them due to the fact that they return to their place of origin.

SPSS version 15.0 software was used as a tool for analysis. Firstly, an analysis of the differential characteristics of patients according to the duration of their stay using either a contrast equal averages, when the variable to compare between the two groups (intermediate stay vs prolonged stay) was quantitative or Chi-square test, when the variable analyzed was qualitative. For both tests, the existence of significant differences between groups was considered when the significance level was less than 5%. Secondly, a predictive model of survival in the ICU of these patients, regardless of length of stay in the ICU, was performed by analyzing binary logistic regression, using as a method of building block model, not proceeding therefore, a definition of the introduction rule or output variables in the model. However, the maximum likelihood model was chosen.

**RESULTS**

During the study period, from 2004 to 2010 inclusive, 6,069 patients were admitted to the ICU, of who 1,906 (31.4%) were surgical, and 540 (28.33%) of those required a stay over 5 days, which is the study population of the present study. To meet the objectives of this study, firstly, an analysis of differences in personal, clinical, and prognosis characteristics of surgical patients based on length of stay (intermediate vs prolonged) was done. The results are shown in Table 1, where no significant differences were observed in the majority of variables analyzed. However, statistical differences in the hospital stay, and the need for MV and tracheotomy were observed with the group of prolonged ICU stay, which showed higher levels in these three variables.

Therefore, it can be said that longer duration of stay entails a greater need for invasive techniques. Nevertheless, it is noted that ICU mortality was significantly higher in patients of intermediate stay compared to those of prolonged stay (30 and 17.5%, respectively); the occurrence is not same with hospital mortality. Finally we proceeded to estimate a logistic regression model aimed at predicting survival in surgical ICU patients with intermediate or prolonged stay, although altogether to avoid very small samples that lead to unreliable results.

In this logistic regression model, the ICU survival was used as the dependent variable, and as independent variables those available in the database and that could, according to the literature reviewed, affect patient survival, such as: Length of stay before ICU admission (pre-ICU), APACHE II, age, days of MV, and days of CRR as quantitative variables; and gender and reason for admission as qualitative variables. The gender and the need for tracheotomy have dichotomous character, not being necessary its recodification, although positive values (value 1) corresponded to the man and need to perform a tracheotomy categories.

As to the reason for admission variable, only the four most frequent reasons (monitoring, acute respiratory failure, coma, and septic shock) were considered, proceeding to create four dichotomous variables, which are the ones that were included in the model. The results of this regression analysis for surgical patients [Table 2] show that the factors that best define survival, introducing the Wald statistic levels above or very close to 5% significance, are the APACHE II, age, having entered in a coma state, and the use of the three invasive techniques discussed. Thus, surgical patients with intermediate or long stay in the ICU will have better prognosis when they have low APACHE II levels, younger age, do not enter in the ICU in a coma state, requiring fewer days of MV and CRR, and finally, if a tracheotomy has been performed.
The predictive nature of both APACHE II and age might be, at first, due to the relationship between both factors ($r = 0.398$, $P = 0.000$); this is, from the existence of multicollinearity. Therefore, we proceeded to make two logistic regression analyses with the same variables except the APACHE II and the age. The results of both analyzes showed that both the APACHE II ($Wald = 27.172$, $P = 0.000$) and age ($Wald = 25.784$, $P = 0.000$) were still two significant predictors of survival. With this model it is able to predict with 93.8% of accuracy the survival of the group of patients who were discharged alive from the ICU; but it is not possible to predict the survival of the group who died (25.8%). In statistical terms, this means that the model is able to correctly predict 77.3% of surgical patients with intermediate or long stay. Likewise, the model presents a Nagelkerke $R^2$, which measures the overall fit of the model, of 0.275 and a Hosmer and Lemeshow value, which measures the correspondence of actual and predicted values of the dependent variable, of 15.266, which it is not significant at a 5% level; indicating an adequate model adjustment.

Table 1: Differences in personal, clinical, and prognosis characteristics of surgical patients based on length of stay (intermediate vs prolonged)

| Characteristics                      | Total ($n = 540$) | Intermediate stay (5-13 days) ($n = 283$) | P       |
|--------------------------------------|-------------------|------------------------------------------|---------|
| Age                                  | 58.39 (16.19)     | 58.26 (16.72)                            | 0.840   |
| Male                                 | 323 (59.8%)       | 170 (60.1%)                              | 0.484   |
| APACHE II                            | 15.90 (6.69)      | 15.57 (6.87)                             | 0.241   |
| Stay in ICU, days                    | 16.73 (12.83)     | 8.46 (2.57)                              | 0.000   |
| Hospital stay, days                  | 53.17 (97.48)     | 32.97 (33.22)                            | 0.000   |
| ICU mortality                         | 130 (24.1%)       | 85 (30%)                                 | 0.000   |
| Hospital mortality                   | 52 (12.7%)        | 24 (12.1%)                               | 0.428   |
| Emergency                            | 171 (31.7%)       | 88 (31.1%)                               | 0.890   |
| Surgical ward                        | 269 (49.8%)       | 141 (49.8%)                              | 0.000   |
| Medical ward                         | 12 (2.2%)         | 6 (2.1%)                                 | 0.000   |
| Gynecology ward                      | 15 (2.8%)         | 10 (3.5%)                                | 0.000   |
| Other hospital                        | 25 (4.6%)         | 14 (4.9%)                                | 0.000   |
| Other island                          | 25 (4.6%)         | 11 (3.9%)                                | 0.000   |
| Others                                | 23 (4.3%)         | 13 (4.6%)                                | 0.000   |
| Reason for admission in ICU           |                   |                                          |         |
| Coma                                 | 163 (30.2%)       | 89 (31.4%)                               | 0.180   |
| Monitoring                           | 92 (17.0%)        | 42 (14.8%)                               | 0.000   |
| Acute respiratory failure             | 116 (21.5%)       | 60 (21.2%)                               | 0.000   |
| Cardiorespiratory arrest              | 8 (1.5%)          | 2 (0.7%)                                 | 0.000   |
| Septic shock                         | 108 (20.0%)       | 56 (19.8%)                               | 0.000   |
| Others shocks                         | 36 (6.7%)         | 21 (7.4%)                                | 0.000   |
| Reasons                              | 17 (3.1%)         | 13 (4.6%)                                | 0.000   |
| Mechanical ventilation                |                   |                                          |         |
| Patients                             | 505 (93.5%)       | 253 (89.4%)                              | 0.000   |
| Days                                 | 13.33 (12.24)     | 6.28 (4.02)                              | 0.000   |
| Tracheotomy                          | 200 (37%)         | 39 (13.8%)                               | 0.000   |
| CRR Patients                         | 32 (5.9%)         | 19 (6.7%)                                | 0.000   |
| Days                                 | 0.43 (2.27)       | 0.33 (1.50)                              | 0.000   |

Quantitative variables: Median (SD); qualitative variables: $n$ (%). CRR: Continuous renal replacement, ICU: Intensive care unit, APACHE II: Acute Physiology and Chronic Health Evaluation II

Table 2: Logistic regression model aimed at predicting survival in surgical ICU patients with intermediate or prolonged stay

| Factors                   | $B$    | Odds ratio | 95% CI       | Wald    | $P$   |
|---------------------------|--------|------------|--------------|---------|-------|
| Stay pre-ICU              | -0.011 | 0.930      | 0.973-1.006  | 1.508   | 0.219 |
| APACHE II                 | -0.073 | 0.930      | 0.895-0.966  | 13.878  | 0.000 |
| Age                       | -0.033 | 0.967      | 0.950-0.984  | 13.833  | 0.000 |
| Male                      | 0.051  | 1.052      | 0.664-1.668  | 0.047   | 0.829 |
| Monitoring                | -0.293 | 0.746      | 0.331-1.678  | 13.833  | 0.000 |
| Acute respiratory failure | -0.456 | 0.634      | 0.289-1.494  | 13.833  | 0.000 |
| Coma                      | -0.875 | 0.417      | 0.180-0.968  | 13.833  | 0.000 |
| Septic shock              | 0.075  | 1.078      | 0.473-2.457  | 0.000   | 0.858 |
| Mechanical ventilation, days | -0.053 | 0.949      | 0.927-0.971  | 0.000   | 0.858 |
| CRR, days                 | -0.101 | 0.904      | 0.820-0.996  | 0.000   | 0.858 |
| Tracheotomy               | 2.004  | 7.418      | 3.822-14.396 | 0.000   | 0.858 |

CRR: Continuous renal replacement, CI: Confidence interval, ICU: Intensive care unit, APACHE II: Acute Physiology and Chronic Health Evaluation II

The predictive model has quite acceptable discrimination ability, if it has a value higher than 0.50.
DISCUSSION

From the results of our study, we can conclude that patients who survive in the ICU, regardless of their length of stay, have the same chances of survival (>85%). This fact has already been observed by other authors, such as Weiler et al., where they saw that their postoperative patients from major abdominal and thoracic surgery and who spent more days in the ICU had similar chances of survival than those who remained least.\[8\]

In the survival analysis, we found that surgical patients with intermediate or long stay in the ICU will have a better prognosis when they have low APACHE II at admission, younger age, have not entered in a coma state, fewer days of MV, and CRR requirements, and finally, that a tracheotomy have been performed. The fact that tracheotomy affects the prognosis of patients in the long-term can only be checked when large-scale randomized controlled studies is carried. We might have missed, in the present study, factors associated with the decision to perform a tracheostomy that might alter outcomes, as weaning failure, nosocomial pneumonia, etc.

The APACHE II prognostic index has been widely used to evaluate the prognosis of critically-ill patients and our results agree with those reported by other authors, which have pointed it out as an index, with high sensitivity and specificity that can predict prognosis and death risk in critically ill patients, either medical or surgical.\[9\]

In conclusion, surgical patients that survive in the ICU, regardless of their length of stay; have the same odds of hospital survival. Furthermore, only APACHE II, age, entering in a coma state, and the necessity of applying invasive techniques were demonstrated as predictors of mortality in the ICU.
Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Barie PS, Hydo LJ, Fischer E. Utility of illness severity scoring for prediction of prolonged surgical critical care. J Trauma 1996;40:513-8.
2. Knaus WA, Wagner DP, Zimmerman JE, Draper EA. Variations in mortality and length of stay in intensive care units. Ann Intern Med 1993;118:753-61.
3. Vincent JL, de Mendonca A, Cantraine F, Moreno R, Takala J, Suter PM, et al. Use of SOFA score to assess the incidence of organ dysfunction/failure in intensive care units: Results of a multicenter, prospective study. Working group on “sepsis-related problems” of the European Society of Intensive Care Medicine. Crit Care Med 1998;26:1793-800.
4. Hartl WH, Wolf H, Schneider CP, Fertmann J, Küchenhoff H, Jauch KW. Significance of multiple organ failure for the prognosis of surgical intensive care patients. Dtsch Med Wochenschr 2006;131:2456-60.
5. Combes A, Luyt CE, Nieszewska S, Trouillet JL, Gibert C, Chastre J. Is tracheostomy associated with better outcomes for patients requiring long-term mechanical ventilation? Crit Care Med 2007;35:802-7.
6. Fertmann J, Wolf H, Kuchenhoff H, Hofner B, Jauch KW, Hartl WH. Prognostic factors in critically ill surgical patients requiring continuous renal replacement therapy. J Nephrol 2008;21:909-18.
7. Heyland DK, Konopad E, Noseworthy TW, Johnston R, Gafni A. Is it worthwhile to continue treating patients with a prolonged stay (> 14 days) in the ICU? An economic evaluation. Chest 1998;114:192-8.
8. Weiler N, Waldmann J, Bartsch DK, Rolles C, Fendrich V. Outcome in patients with long-term treatment in a surgical intensive care unit. Langenbecks Arch Surg 2012;397:995-9.
9. Barie PS, Hydo LJ, Fischer E. Comparison of APACHE II and III scoring systems for mortality prediction in critical surgical illness. Arch Surg 1995;130:77-82.
10. Bagshaw SM, Mortis G, Doig C, Godinez-Luna T, Fick GH, Laupland KB. One-year mortality in critically ill patients by severity of kidney dysfunction: A population-based assessment. Am J Kidney Dis 2006;48:402-9.
11. Schiffl H, Fischer R. Five-year outcomes of severe acute kidney injury requiring renal replacement therapy. Nephrol Dial Transplant 2008;23:2235-41.
12. Forrest JB, Rehder K, Cahalon MK, Goldsmith CH. Multicenter study of general anesthesia: III. Predictors of severe perioperative adverse outcomes. Anesthesiology 1992;76:3-15.
13. Isgro F, Skuras JA, Kiessling AH, Lehmann A, Saggau W. Survival and quality of life after a long-term intensive care stay. Thorac Cardiovasc Surg 2002;50:95-9.
14. Niskanen M, Ruokonen E, Takala J, Rissanen P, Kari A. Quality of life after prolonged intensive care. Crit Care Med 1999;27:1132-9.
15. Trouillet JL, Scheiberg A, Vuagnat A, Fagon JY, Chastre J, Gibert C. Long-term outcome and quality of life of patients requiring multidisciplinary intensive care unit admission after cardiac operations. J Thorac Cardiovasc Surg 1996;112:926-34.
16. Gharsallah H, Hajiej Z, Naas I, Aouni Z, Stambouli N, Labbène I, et al. Assessment of nutritional status and prognosis in surgical intensive care unit: The prognostic and inflammatory nutritional index (PINI). Int J Nutr Food Sci 2014;3:477-83.