Characteristics and Survival of Patients with Acute Traumatic Spinal Cord Injury Above T6 with Prolonged Intensive Care Unit Stays

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Abstract

Objective. To characterize patients with acute traumatic spinal cord injury (ATSCI) above T6 who were admitted to the intensive care unit (ICU) for ≥30 days and their 1-year mortality compared with patients admitted for <30 days.

Methods. A retrospective observational study was performed on 211 patients with an acute traumatic spinal cord injury above T6 who were admitted to an ICU between 1998 and 2017. Multivariate logistic regression analysis was performed to determine the relationship between an ICU stay ≥30 days and mortality after ICU discharge.

Results. Of patients, 29.4% were admitted to the ICU for ≥30 days, accounting for 53.4% of total days of ICU stays generated by all patients. An ICU stay ≥30 days was not identified as an independent risk factor for mortality (1-year survival: 88.5% vs. 88.1%; adjusted hazard ratio [HR] 0.80, $P = 0.699$). Variables identified as predictors of 1-year post–ICU discharge mortality were severity at admission according to the Acute Physiology and Chronic Health Evaluation II score (HR 1.18) and the American Spinal Injury Association Impairment Scale motor score (HR 0.97). Among patients who required invasive mechanical ventilation, a longer duration of the respiratory support was associated with increased mortality (HR 1.01).

Conclusions. Three out of 10 patients with acute traumatic spinal cord injury above T6 require prolonged stays in the ICU. Variables found to be associated with 1-year post–ICU discharge mortality in these patients were American Spinal Injury Association Impairment Scale motor score, severity, and greater duration of invasive mechanical ventilation, but not an ICU stay ≥30 days.

Key words

Acute traumatic spinal cord injury; Critical care; Hospital mortality; Length of stay; Prospective study; Survival

Abbreviations and Acronyms

AIS, American Spinal Injury Association Impairment Scale; APACHE, Acute Physiology and Chronic Health Evaluation; ATSCI, Acute traumatic spinal cord injury; CCI, Charlson Comorbidity Index; CI, Confidence Interval; GCS, Glasgow Coma Scale; HR, Hazard ratio, ICU, Intensive care unit; IMV, Invasive mechanical ventilation; ISS, Injury Severity Score; SOFA, Sequential Organ Failure Assessment

INTRODUCTION

The advances in health care achieved in recent decades demand intensive care unit (ICU) admissions of a greater number of patients for the treatment of more complex conditions,[1] which constitutes a clinical and economic challenge.[2] In addition, this greater complexity of patients' conditions entails prolonged ICU stays. Despite this, the long-term outcomes of patients with prolonged ICU stays remain undetermined. Some studies suggest that a prolonged stay in the ICU can increase the likelihood of both in-hospital and out-of-hospital mortality at 1 year,[3-5] while others report no such increase in mortality in relation to a lengthy ICU stay.[6,7] This divergence in results may be explained by the definition of prolonged stay of each study, the different populations analyzed, the conditions evaluated, and the severity of the injuries under study.[8]

In this sense, prolonged ICU stays of patients with severe traumatic injuries significantly increase health care costs, but may be associated with acceptable mortality rates. The available literature includes a very limited number of studies analyzing the prognosis of trauma patients requiring longer ICU stays,[6,7] and, to our knowledge, none of them specifically analyzed the expected survival of the population of patients admitted to the ICU for acute traumatic spinal cord injury (ATSCI). This type of injury, particularly above T6, frequently causes respiratory and hemodynamic dysfunction, depending on the injury level and degree.[9] Thus, complications such as multiorgan failure or sepsis and consequently prolonged hospital stays are more frequent among patients with this condition.[10] The primary aim of this study was to characterize patients with ATSCI above T6 who were admitted to the ICU for ≥30 days. In addition, we sought to analyze their evolution over 1 year in terms of mortality compared with patients who were admitted to the ICU for <30 days.

MATERIALS AND METHODS

An observational, retrospective follow-up study was conducted on patients with ATSCI above T6 who were admitted to the ICU of the University Hospital Complex of A Coruña (Complexo Hospitalario Universitario de A Coruña) between January 1998 and December 2017. This hospital is a referral center for treatment of patients with ATSCI in a region in the northwest of Spain with 2,750,000 inhabitants. The study design was previously described in another study[11] and was approved by the Research Ethics Committee.

Three different time periods (1998–2005, 2006–2011, and 2012–2017) were analyzed, determined by changes in the health care of patients with ATSCI. In 2004, the intensive care physicians began performing percutaneous tracheostomies in the hospital. In 2012, there was a change of strategy in the initial hemodynamic management of these patients (mean arterial pressure was adjusted to 85 mm Hg to ensure spinal cord perfusion pressure, and routine administration of corticosteroids was discontinued).

A total of 241 adult patients (>18 years old) with ATSCI above T6 were admitted to the ICU during the study period. Of these, 30 died during their stay in the ICU. Thus, a final total of 211 patients who were eventually discharged from the ICU were included in this study. Patients who had a short stay (<30 days) in the ICU were compared with patients who had a prolonged stay (≥30 days) (Figure 1). Albeit arbitrary, this cutoff point was selected because the characteristics of this sort of injury warrant a prolonged ICU stay, with the mean ICU length of stay being 23.8 ± 15.8 days (median = 23 days).

The following were collected for all patients: sociodemographic variables (age and sex); comorbidity assessed according to the age-adjusted Charlson Comorbidity Index (CCI); injury variables (mechanism, affected neurological level, American Spinal Injury Association Impairment Scale [AIS] grade, AIS motor score, Glasgow Coma Scale score, and polytrauma Injury Severity Score [ISS]); severity variables (Acute Physiology and Chronic Health Evaluation [APACHE] II score within the first 24 hours of admission and Sequential Organ Failure Assessment [SOFA] score on days 0 and 4); organ support variables (fluid balance on day 4—defined as the difference between fluid intake and loss during the resuscitation phase—and invasive mechanical ventilation [IMV]); surgical treatment; nosocomial infections (pneumonia, urinary tract infection, primary bacteremia, and catheter-related infection); length of stay (in the ICU and post-ICU hospitalization); and mortality (post-ICU in-hospital mortality and 1-year post–ICU discharge mortality).

A bivariate analysis of the collected information was performed comparing the patients according to the length of their stay in the ICU (<30 days vs. ≥30 days). After confirming normality of the data with the Kolmogorov-Smirnov test, quantitative variables were compared using Student *t* test or Mann-Whitney test. A percentage comparison was performed using the χ^2 test or Fisher exact test. Kaplan-Meier curves were used to estimate the patients' survival following their discharge from the ICU, comparing the results of both groups with the log-rank test. To determine the impact of a prolonged ICU stay on the prognosis of these patients, a multivariate analysis, adjusted by other covariables, was performed using the Cox proportional hazards model, calculating the associated hazard ratios (HRs) and 95% confidence intervals (CIs). The statistical analyses were carried out with IBM SPSS Version 25.0 for Windows (IBM Corporation, Armonk, New York, USA), with bilateral P values <0.05 being considered statistically significant.

RESULTS

Of the 211 patients with ATSCI above T6 who were discharged from the ICU, 149 (70.6%) had a short stay of <30 days (mean = 15.7 ± 8.9 days; median = 16 days), and 62 (29.4%) had a long stay of ≥30 days (mean = 43.3 ± 11.0 days; median = 40 days) (Figures 1 and 2). The percentage of long-stay patients decreased over the study period, from 43.5% in the 1998–2005 period to 21.0% in the 2012–2017 period. Thus, long-stay patients accounted for 53.4% of the total days of ICU stays throughout the study period (2638 days of a total of 5023 days of ICU hospitalization).

Patient Characteristics According to Their Length of Stay in ICU

Compared with patients who stayed in the ICU for <30 days, patients who stayed ≥30 days had a significantly higher percentage of injuries with an AIS grade A (67.2% vs. 43.9%), a lower AIS motor score (22.9 ± 23.0 vs. 41.6 ± 27.1, P < 0.001), and higher SOFA scores on days 0 (6.0 ± 2.9 vs. 4.6 ± 2.6, P = 0.001) and 4 (4.8 ± 2.7 vs. 4.0 ± 2.03, P = 0.048). No differences were observed between the 2 groups in terms of demographic characteristics, comorbidity, ISS, affected neurological level, or severity of condition at admission as measured by the APACHE II (Table 1). As expected, patients with an ICU stay ≥30 days required IMV more frequently and for longer periods, had a higher fluid balance (difference between fluid intake and loss after 4 days), required a tracheostomy more often, and had a greater incidence of nosocomial infections (Table 1).

The median age of the patients who had to be hospitalized in the ICU for ≥30 days increased throughout the study period (48 years during the 1998–2005 period vs. 64 years during the 2012–2017 period). In contrast, no changes were observed in the male-to-female ratio over this period. During the last study period, the patients had higher AIS motor scores (median of 13 vs. 29.5), higher APACHE scores at admission (median of 9 vs. 14), a trend toward worse SOFA scores, and no differences in the AIS grade and ISS. The fluid balance was also increasingly restrictive in this group of patients (7.34 ± 2.85 L during the first study period and 4.85 ± 2.79 L during the last one). The number of long-stay patients who required an early tracheostomy increased throughout the study period (19.2% vs. 27.3% vs. 30.8% for 1998–2005, 2006–2011, and 2012–2017, respectively), thus resulting in a concurrent decrease in the duration of the IMV. No changes were observed in the incidence of nosocomial infections in these patients throughout the study period (Table 2).

1-Year Post–ICU Discharge Survival According to Length of Stay in ICU

The required follow-up of 1 year after ICU discharge could not be completed in 12 patients (8 patients with a stay <30 days and 4 with a stay ≥30 days). Of the patients with a stay <30 days whose follow-up could be completed, 11.4% died within 1 year of discharge from the ICU (9.4% in the hospital) with a mean survival time of 4.8 ± 4.0 months (88.1% likelihood of 1-year survival). Of patients with a stay ≥30 days, 11.3% died within 1 year (all during post-ICU hospital stay) with a mean survival time of 4.7 ± 3.4 months (88.5% likelihood of 1-year survival). Thus, no significant differences were observed between the 1-year survival rates of the 2 groups (Figure 3).

Bivariate analysis revealed that the characteristics associated with mortality within 1 year following a patient's discharge from the ICU were older age, higher CCI, worse AIS motor score, greater severity of the patient's condition at admission according to the APACHE II and SOFA scores, and worse Glasgow Coma Scale score at discharge. Only 2 of the 24 recorded deaths corresponded to patients who had not required IMV. In patients who did require IMV, the duration of IMV also constituted a prognostic variable (Table 3).

The multivariate analysis did not identify ICU stay ≥30 days as an independent factor contributing to mortality of these patients. Variables that were identified as predictors of 1-year post–ICU discharge mortality in the analysis were severity at admission according to the APACHE II scale (HR 1.18, 95% CI 1.07–1.30) and AIS motor score (HR 0.97, 95% CI 0.95–0.99) (Table 3). Among patients who required IMV, a longer duration of respiratory support was also associated with increased mortality (HR 1.01, 95% CI 1.01–1.02) (data not shown in tables).

DISCUSSION

The results of this study revealed 3 main findings. First, patients who survive an ICU stay ≥30 days comprise a significant group (29.38%) within the population of patients admitted to the ICU with ATSCI above T6 and account for >50% of the days of stay at this unit by patients with this condition. The cutoff point for the length of stay was established considering that the mean length of ICU stay of patients with ATSCI is greater than that of other trauma patients.[12] Although these figures may seem high compared with those reported in other studies on trauma patients, they can be explained by the fact that, in our study, we specifically analyzed a subgroup of patients with ATSCI above T6, a condition associated with an increased risk of dysfunction and death.

Hence, the percentage of patients with a prolonged ICU stay reported in our study is much higher than that described by other authors with regard to populations admitted to the ICU for other types of trauma. For example, Martin et al.[5] described a prolonged stay in 5.6% of the trauma patients included in their study cohort, Trottier et al.[8] reported a stay >28 days in 9.5% of their patient population, and Ong et al.[13] recorded a stay >30 days in 4%

of the trauma patients included in their analysis. Similarly, in a case series including critically ill patients with a medical condition, Hughes et al.[14] reported 1.6% of patients with an ICU stay ≥30 days. Bashour et al.[15] also reported a stay ≥10 days in 5.4% of the surgical patients evaluated in their study. This is likely related to the characteristics of the injury and its impact on the respiratory and hemodynamic functions of the patients,[16-18] despite the fact that our study population mostly consisted of young patients with few associated lesions.

The profile of the group of patients with a prolonged ICU stay was characterized by a mean age of about 50 years and a low CCI and differed from that of the short-stay patients in terms of the characteristics of injuries (higher percentage of spinal cord injuries with an AIS grade A and a worse motor index). However, in contrast to other case series involving trauma patients,[6] these patients did not have more associated injuries (similar ISS and Glasgow Coma Scale score). All (100%) patients in this group required IMV and had a greater severity at admission and on day 4 (measured according to the SOFA scale), which could explain the greater number of days elapsed until the spinal fixation surgery. Other authors have also described a greater severity, as measured by different scales, in other patients in critical condition with prolonged ICU stays. Stricker et al.[3] also observed a greater Simplified Acute Physiology Score among surgical, trauma, and medical patients with a stay >7days (31.1 ± 14.9 vs. 42.5 ± 16.5, $P < 0.001$), and Martin et al.[5] reported a greater APACHE II score among critically ill patients with a prolonged stay (17.4 ± 7.5 vs. 23.2 ± 7.0, $P < 0.0001$). The results of our study suggest that the prolonged length of stay in the ICU among patients with the condition under study might be more related to the characteristics of the ATSCI, its impact on organ function, and the risk of infectious complications. In a previous study carried out by our group, the patients who died in the ICU were older and had greater comorbidity; these variables were probably not part of the equation when we analyzed patients who survived a stay ≥30 days, as described by Ong et al.[13] in a case series of trauma patients.

Second, the percentage of patients with ATSCI above T6 who survived following a prolonged ICU stay decreased over the years (43.5% vs. 21.0%). This could be explained by more active care by the team of specialists at the Spinal Cord Injury Unit, who in recent years have been attending patients weaning from prolonged IMV. This means that patients with a prolonged ICU stay who previously remained in the ICU exclusively because of this criterion are now cared for in the standard ward. However, we found no differences in this respect among the patients with a prolonged stay between the different study periods. Thus, although the mean length of ICU stay has globally decreased throughout the years, probably in relation to factors related to the characteristics of the injuries,[19] the improvement in the quality of care over the last few decades, and the criteria defining discharge, patients who survive after a prolonged ICU stay (≥30 days) have a 1-year survival rate similar to patients with a shorter stay (<30 days). This information is useful in reassuring families, raising awareness among health care teams about the usefulness of their efforts, and encouraging managers of health care institutions to sustain the expenses of this care.

Third, regarding their clinical evolution, patients with ATSCI above T6 who survived an ICU stay ≥30 days had a 1-year mortality rate of 11.3%, similar to patients admitted for a shorter period of time (11.4%), with these deaths essentially occurring during the post-ICU hospital stay. These percentages are equal to or greater than percentages published for trauma patients. For example, in their studies, Trottier et al.[8] described a survival rate of 86.7% among patients with a stay >28 days, Ong et al.[13] observed a survival rate of 88% among patients with a stay >30 days, Goins et al.[19] reported a mortality rate of 17.2% among patients with a stay >30 days, and Kisat et al.[20] calculated a mortality rate of 9.8%

among patients with a stay >40 days. These results are maintained even when compared with case series in which a prolonged stay was defined by the authors as a shorter period than in our study, such as in the case of Miller et al.,[6] who reported a mortality rate of 22% among patients with a mean stay of 3 weeks. Hence, this demonstrates that prolonged ICU stays do not result in a decrease in patient survival compared with shorter stays.

Regarding the variables identified as predictors of mortality, age has been described as a determining factor in other studies concerning trauma patients,[8,20,21] and comorbidity has also been shown to play a role in survival,[13] as confirmed by our results using the age-adjusted CCI. These findings were not confirmed with the multivariate analysis, probably because our patient population mostly consisted of young patients without any significant comorbidity. The type of spinal cord injury is a well-studied variable, with a worse prognosis being associated with injuries at higher levels and a worse AIS grade.[10,22] The patient's severity on admission to the ICU, as measured by SOFA,[23] APACHE II,[24-26] or Simplified Acute Physiology Score,[27] has demonstrated a good correlation with intra-ICU mortality in other patient populations. The specific model described in this study proves that, beyond conventional variables, the severity at admission to the ICU, as measured by APACHE II, is a good predictor of mortality at discharge in patients with ATSCI above T6. The APACHE II score reflects the degree of dysfunction present at admission, while considering the patient's age and aspects related to comorbidity and functional reserve. In the subgroup of patients requiring IMV, ventilatory dependence is also a prognostic indicator, as reported by Inglis et al.[22] in their analysis of a population of patients ≥65 years of age with ATSCI. However, when considering these variables, a prolonged ICU stay is not a predictor of 1-year mortality.

LIMITATIONS

Although this study was carried out with the maximum methodological guarantees, it might have some limitations. First, although this is a study focusing on a homogeneous population of patients referred from a regional reference hospital, there is no registry available for the reference area, and the results could have been affected by the non-inclusion of patients who had died before being transferred to our hospital. Moreover, given that 12 patients were lost to follow-up, the survival rate could have been overestimated. Second, the retrospective nature of our study might have resulted in an information bias; however, it must be noted that our ICU registries are exhaustive and guarantee the reliability of the collected data. Third, despite considering the comorbidity as measured by the CCI, other comorbidities not included in the CCI as well as the patient's frailty or body mass index, could have had an impact on the prognosis. Furthermore, we analyzed only the survival and not the quality of life or functional status after the injury. The 30-day ICU stay limit in our study allowed us to compare our results with those reported by other authors who used a similar cutoff point. In addition, given that ATSCI above T6 frequently causes respiratory and hemodynamic dysfunction, complications and prolonged stays are more frequent among patients with this condition. Finally, it should be noted that the aim of this study was not to analyze the factors associated with a prolonged stay, but rather to describe the profile and clinical evolution of patients with a long ICU stay to confirm that although they consume a large amount of the resources allocated to patients with the condition under study, they have a favorable evolution that does not differ from that of patients with shorter stays.

CONCLUSIONS

To the best of our knowledge, this is the first study to assess the evolution in terms of mortality of patients with ATSCI above T6 with a prolonged ICU stay. The results demonstrate that a high percentage of patients with ATSCI above T6 require an ICU stay ≥30 days. Despite the high resource consumption, after a prolonged ICU stay, these patients have high survival rates similar to those of patients with shorter stays. The variables associated with mortality after ICU discharge identified in our study were the AIS motor score and severity of the patient's condition at ICU admission (APACHE II score), while a stay ≥30 days was not found to have an impact on such mortality.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Inés Esmorís-Arijón: Conceptualization, Methodology, Funding acquisition, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Rita Galeiras:** Methodology, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Sebastián Salvador de la Barrera:** Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Mónica Mourelo Fariña:** Conceptualization, Methodology, Funding acquisition, Writing – review & editing. **Sonia Pértega Díaz:** Methodology, Formal analysis, Data curation, Writing – original draft, Writing – review & editing.

REFERENCES

1. Bion JF, Bennett D. Epidemiology of intensive care medicine: supply versus demand. *Br Med Bull*. 1999;55:2-11.
2. Ryan TA, Rady MY, Bashour CA, Leventhal M, Lytle B, Starr NJ. Predictors of outcome in cardiac surgical patients with prolonged intensive care stay. *Chest*. 1997;112:1035-1042.
3. Stricker K, Rothen HU, Takala J. Resource use in the ICU: short- vs. long-term patients. *Acta Anaesthesiol Scand*. 2003;47:508-515.
4. Wong DT, Gomez M, McGuire GP, Kavanagh B. Utilization of intensive care unit days in a Cana- dian medical-surgical intensive care unit. *Crit Care Med*. 1999;27:1319-1324.
5. Martin CM, Hill AD, Burns K, Chen LM. Char- acteristics and outcomes for critically ill patients with prolonged intensive care unit stays. *Crit Care Med*. 2005;33:1922-1927.
6. Miller RS, Patton M, Graham RM, Hollins D. Outcomes of trauma patients who survive pro- longed lengths of stay in the intensive care unit. *J Trauma*. 2000;48:229-234.
7. Chaudhary MA, Schoenfeld AJ, Koehlmoos TP, Cooper Z, Haider AH. Prolonged ICU stay and its association with 1-year trauma mortality: an analysis of 19,000 American patients. *Am J Surg*. 2019;218:21-26.
8. Trottier V, McKenney MG, Beninati M, Manning R, Schulman CI. Survival after pro- longed length of stay in a trauma intensive care unit. *J Trauma*. 2007;62:147-150.
9. West CR, Mills P, Krassioukov AV. Influence of the neurological level of spinal cord injury on cardiovascular outcomes in humans: a meta- analysis. *Spinal Cord*. 2012;50:484-492.
10. Stephan K, Huber S, Häberle S, et al. Spinal cord injury—incidence, prognosis, and outcome: an analysis of the TraumaRegister DGU. *Spine J*. 2015; 15:1994-2001.

11. Arijón IE, Galeiras R, Quiroga LS, Velasco MEF, Pértega Díaz S. Trends in the presentation and management of traumatic spinal cord lesions above T6: 20-year experience in a tertiary-level hospital in Spain [e-pub ahead of print]. *J Spinal Cord Med*. https://doi.org/10.1080/10790268.2020. 1851857, accessed January 14, 2021.

12. Pickett GE, Campos-Benitez M, Keller JL, Duggal N. Epidemiology of traumatic spinal cord injury in Canada. *Spine (Phila Pa 1976)*. 2006;31: 799-805.

13. Ong AW, Omert LA, Vido D, et al. Characteristics and outcomes of trauma patients with ICU lengths of stay 30 days and greater: a seven-year retro- spective study. *Crit Care*. 2009;13:R154.

14. Hughes M, MacKirdy FN, Norrie J, Grant IS. Outcome of long-stay intensive care patients. *Intensive Care Med*. 2001;27:779-782.

15. Bashour CA, Yared JP, Ryan TA, et al. Long-term survival and functional capacity in cardiac surgery patients after prolonged intensive care. *Crit Care Med*. 2000;28:3847-3853.

16. Grigorean VT, Sandu AM, Popescu M, et al. Car- diac dysfunctions following spinal cord injury. *J Med Life*. 2009;2:133-145.

17. Berlowitz DJ, Wadsworth B, Ross J. Respiratory problems and management in people with spinal cord injury. *Breathe (Sheff)*. 2016;12:328-340.

18. DeVeau KM, Martin EK, King NT, et al. Chal- lenging cardiac function post-spinal cord injury with dobutamine. *Auton Neurosci*. 2018;209:19-24.

19. Goins WA, Reynolds HN, Nyanjom D, Dunham CM. Outcome following prolonged intensive care unit stay in multiple trauma pa- tients. *Crit Care Med*. 1991;19:339-345.

20. Kisat MT, Latif A, Zogg CK, et al. Survival out- comes after prolonged intensive care unit length of stay among trauma patients: The evidence for never giving up. *Surgery*. 2016;160:771-780.

21. Johnson CL, Margulies DR, Kearney TJ, Hiatt JR, Shabot MM. Trauma in the elderly: an analysis of outcomes based on age. *Am Surg*. 1994;60:899-902.

22. Inglis T, Banaszek D, Rivers CS, et al. In-hospital mortality for the elderly with acute traumatic spinal cord injury. *J Neurotrauma*. 2020;37: 2332-2342.

23. Ferreira FL, Bota DP, Bross A, Mélot C, Vincent JL. Serial evaluation of the SOFA score to predict outcome in critically ill patients. *JAMA*. 2001;286: 1754-1758.

24. Barie PS, Hydo LJ, Fischer E. Utility of illness severity scoring for prediction of prolonged sur- gical critical care. *J Trauma*. 1996;40:513-518 [dis- cussion: 518-519].

25. Aslar AK, Kuzu MA, Elhan AH, Tanik A, Hengirmen S. Admission lactate level and the APACHE II score are the most useful predictors of prognosis following torso trauma. *Injury*. 2004;35: 746-752.

26. Rutledge R, Fakhry S, Rutherford E, Muakkassa F, Meyer A. Comparison of APACHE II, Trauma Score, and Injury Severity Score as predictors of outcome in critically injured trauma patients. *Am J Surg*. 1993;166:244-247.

27. Shabot MM, Johnson CL. Outcome from critical care in the “oldest old” trauma patients. *J Trauma*. 1995;39:254-259 [discussion: 259-260].

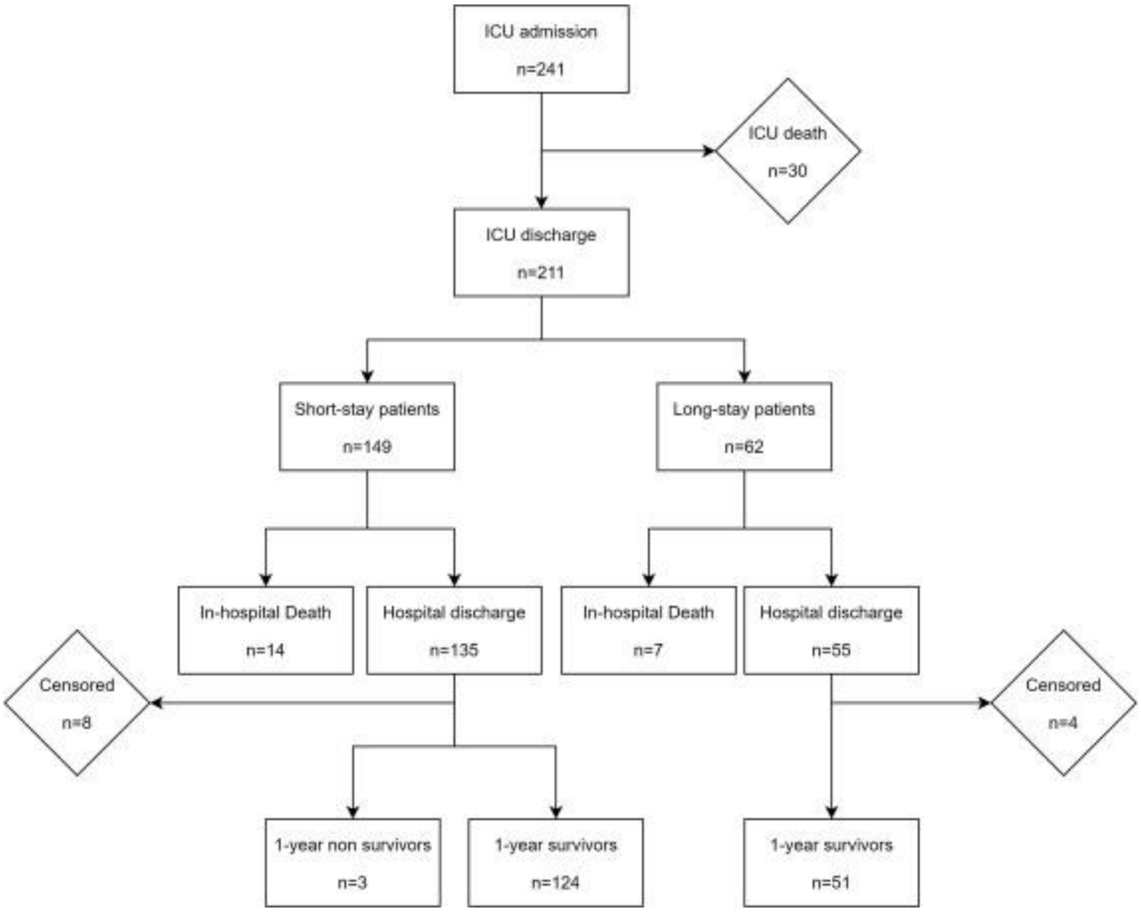

Figure 1. Patient flow chart. ICU, intensive care unit.

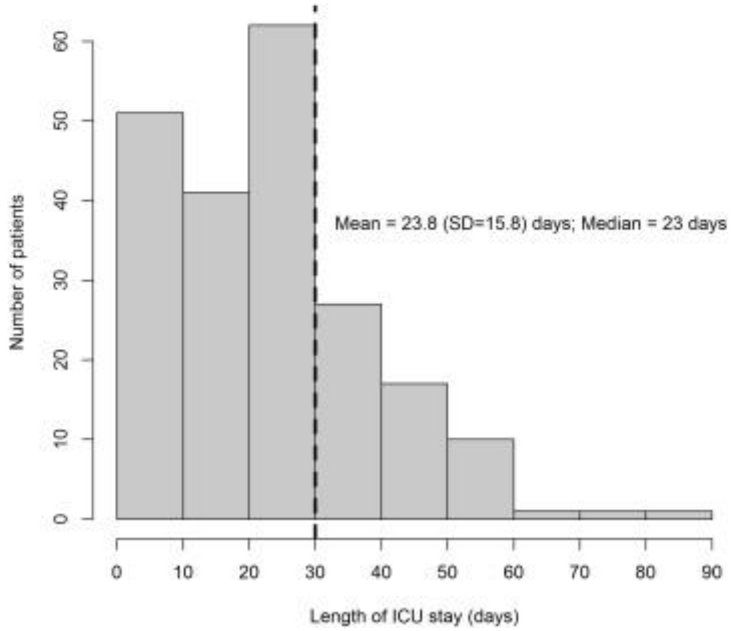

Figure 2. Histogram of length of intensive care unit stay of all patients (N = 211). ICU, intensive care unit.

Table 1. Baseline Characteristics and Intensive Care Unit Factors in Short-Stay versus Long-Stay Patients

	Short-Stay Patients (n = 149)	Long-Stay Patients (n = 62)	P Value
Admission period			<0.001
1998–2005	23 (15.4%)	27 (43.5%)	
2006–2011	53 (35.6%)	22 (35.5%)	
2012–2017	73 (49.0%)	13 (21.0%)	
Age, years	52.2 ± 19.9 (55.0)	49.4 ± 20.0 (49.0)	0.354
Sex			0.081
Male	111 (74.5%)	53 (85.5%)	
Female	38 (25.5%)	9 (14.5%)	
Injury mechanism			—
Fall	63 (42.3%)	20 (32.8%)	
Fall from a height	19 (12.8%)	6 (9.8%)	
Occupational accident	6 (4.0%)	2 (3.3%)	
Pedestrian collision	7 (4.7%)	4 (6.6%)	
Dive	6 (4.0%)	1 (1.6%)	
Traffic accident	48 (32.2%)	28 (45.9%)	
Neurological level			0.519
C1-C4	48 (32.2%)	24 (38.7%)	
C5-C8	57 (38.3%)	24 (38.7%)	
T1-T6	44 (29.5%)	14 (22.6%)	
AIS grade			0.009
A	65 (43.9%)	41 (67.2%)	
B	19 (12.8%)	8 (13.1%)	
C	36 (24.3%)	8 (13.1%)	
D	28 (18.9%)	4 (6.6%)	
AIS motor score	41.6 ± 27.1 (48.5)	22.9 ± 23.0 (15.0)	<0.001
CCI	0.9 ± 1.7 (0.0)	0.6 ± 1.3 (0.0)	0.159
APACHE II score at admission	11.7 ± 5.9 (11.0)	12.0 ± 6.7 (11.0)	0.914
SOFA score on day 0	4.6 ± 2.6 (4.0)	6.0 ± 2.9 (6.0)	0.001
GCS score at admission	13.8 ± 2.6 (15.0)	12.9 ± 4.1 (15.0)	0.929
ISS	33.2 ± 12.8 (29.0)	33.4 ± 10.6 (27.0)	0.877
SOFA score on day 4	4.0 ± 2.3 (4.0)	4.8 ± 2.7 (4.0)	0.048
Fluid balance on day 4, L	4.2 ± 3.7 (4.2)	6.9 ± 3.2 (7.2)	<0.001
Surgery	77 (51.7%)	38 (61.3%)	0.202

Table 1. Baseline Characteristics and Intensive Care Unit Factors in Short-Stay versus Long-Stay Patients

	Short-Stay Patients (n = 149)	Long-Stay Patients (n = 62)	P Value
Time elapsed between injury onset and surgery, days	11.1 ± 7.9 (11.0)	20.6 ± 14.9 (16.0)	<0.001
IMV	110 (73.8%)	62 (100.0%)	<0.001
Duration of IMV, days	33.0 ± 51.0 (19.0)	56.1 ± 44.9 (42.0)	<0.001
Tracheostomy	73 (49.0%)	61 (98.4%)	<0.001
Early tracheostomy (≤7 days)	30 (41.1%)	15 (24.6%)	0.044
GCS score at discharge	14.8 ± 0.8 (15.0)	14.6 ± 1.5 (15.0)	0.922
Nosocomial infection	86 (57.7%)	54 (87.1%)	<0.001
Post-ICU in-hospital mortality	14 (9.4%)	7 (11.3%)	0.675
Post-ICU hospital stay, days	154.0 ± 81.2 (162.0)	172.2 ± 100.0 (171.0)	0.226
1-year mortality	17 (11.4%)	7 (11.3%)	0.980

Values are presented as number (%) or mean ± SD (median).

AIS, American Spinal Injury Association Impairment Scale; CCI, Charlson Comorbidity Index; APACHE, Acute Physiology and Chronic Health Evaluation; SOFA, Sequential Organ Failure Assessment; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; IMV, invasive mechanical ventilation; ICU, intensive care unit.

Table 2. Comparison of Characteristics of Patients with Length of Stay ≥30 Days Throughout Study Period

	1998–2005 (*n* = 27)	2006–2011 (*n* = 22)	2012–2017 (*n* = 13)
Age, years	48.3 ± 17.5 (48.0)	46.6 ± 22.3 (48.0)	56.5 ± 20.8 (64.0)
Sex			
Male	23 (85.2%)	18 (81.8%)	12 (92.3%)
Female	4 (14.8%)	4 (18.2%)	1 (7.7%)
Injury mechanism			
Fall	8 (29.6%)	8 (36.4%)	4 (33.3%)
Fall from a height	3 (11.1%)	1 (4.5%)	2 (16.7%)
Occupational accident	0 (0.0%)	2 (9.1%)	0 (0.0%)
Pedestrian collision	3 (11.1%)	1 (4.5%)	0 (0.0%)
Dive	0 (0.0%)	1 (4.5%)	0 (0.0%)
Traffic accident	13 (48.1%)	9 (40.9%)	6 (50.0%)
Neurological level			
C1-C4	12 (44.4%)	9 (40.9%)	3 (23.1%)
C5-C8	13 (48.1%)	6 (27.3%)	5 (38.5%)
T1-T6	2 (7.4%)	7 (31.8%)	5 (38.5%)
AIS grade			
A	15 (57.7%)	19 (86.4%)	7 (53.8%)
B	5 (19.2%)	1 (4.5%)	2 (15.4%)
C	5 (19.2%)	1 (4.5%)	2 (15.4%)
D	1 (3.8%)	1 (4.5%)	2 (15.4%)
AIS motor score	17.9 ± 19.0 (13.0)	21.4 ± 21.8 (13.0)	35.8 ± 29.1 (29.5)
CCI	0.1 ± 0.4 (0.0)	0.2 ± 0.5 (0.0)	2.0 ± 2.2 (1.0)
ISS	31.5 ± 11.0 (25.0)	36.3 ± 10.9 (37.5)	32.2 ± 8.8 (25.0)
APACHE II score at admission	10.7 ± 6.8 (9.0)	12.0 ± 5.7 (11.5)	14.8 ± 7.7 (14.0)
GCS score at admission	12.7 ± 4.4 (15.0)	13.4 ± 3.6 (15.0)	12.4 ± 4.4 (15.0)
SOFA score on day 0	5.3 ± 2.8 (5.0)	6.9 ± 3.2 (7.0)	6.2 ± 2.4 (6.0)
SOFA score on day 4	4.4 ± 3.0 (3.0)	4.6 ± 2.3 (4.0)	6.1 ± 2.2 (7.0)
Fluid balance on day 4, L	7.3 ± 2.9 (7.4)	7.7 ± 3.3 (7.9)	4.85 ± 2.8 (4.5)
Surgery	13 (48.1%)	14 (63.6%)	11 (84.6%)
Time elapsed between injury onset and surgery, days	27.6 ± 18.0 (21.0)	16.1 ± 10.5 (14.5)	18.0 ± 13.9 (15.0)
IMV	27 (100.0%)	22 (100.0%)	13 (100.0%)
Duration of IMV	63.3 ± 52.1 (45.0)	58.8 ± 45.2 (42.0)	36.5 ± 15.9 (35.0)
Tracheostomy	26 (96.3%)	22 (100.0%)	13 (100.0%)

Table 2. Comparison of Characteristics of Patients with Length of Stay ≥30 Days Throughout Study Period

	1998–2005 (*n* = 27)	2006–2011 (*n* = 22)	2012–2017 (*n* = 13)
Early tracheostomy	5 (19.2%)	6 (27.3%)	4 (30.8%)
GCS score at discharge	14 ± 2 (15)	15 ± 0 (15)	14 ± 1 (15)
Nosocomial infection	22 (81.5%)	20 (90.9%)	12 (92.3%)
Post-ICU hospital stay, days	160.5 ± 95.3 (164.0)	174.6 ± 108.2 (184.5)	192.9 ± 99.5 (183.0)
In-hospital mortality	2 (7.4%)	1 (4.5%)	2 (15.4%)
1-year post–ICU discharge mortality	2 (7.4%)	3 (13.6%)	2 (15.4%)

Values are presented as number (%) or mean ± SD (median).

AIS, American Spinal Injury Association Impairment Scale; CCI, Charlson Comorbidity Index; ISS: Injury Severity Score; APACHE: Acute Physiology and Chronic Health Evaluation; GCS: Glasgow Coma Scale; SOFA: Sequential Organ Failure Assessment; IMV, invasive mechanical ventilation; ICU, intensive care unit.

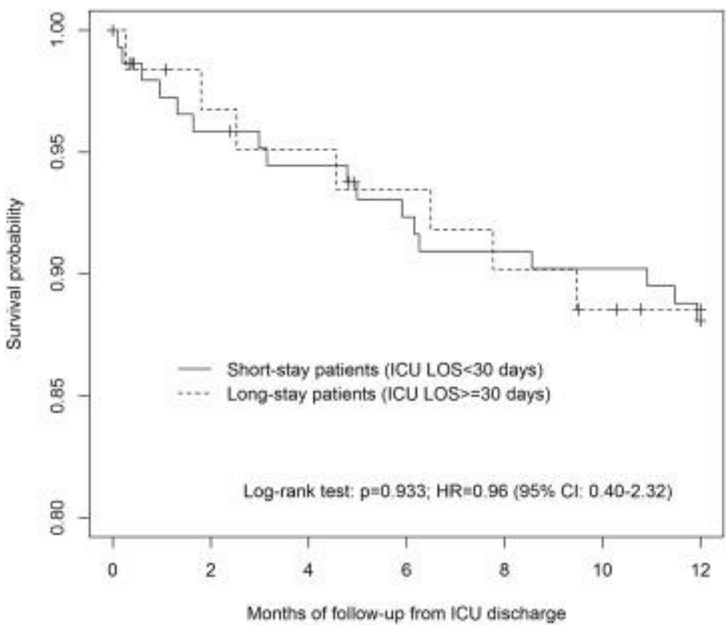

Figure 3. Survival according to the length of intensive care unit stay (1-year post–intensive care unit discharge survival). ICU, intensive care unit; LOS, length of stay; HR, hazard ratio; CI, confidence interval.

Table 3. Bivariate and Multivariate Analysis of Patient Characteristics Associated with 1-Year Post–Intensive Care Unit Discharge Mortality

	Unadjusted			Adjusted		
	P	HR	95% CI	*P*	HR	95% CI
ICU stay ≥30 days	0.933	0.96	0.40–2.32	0.699	0.80	0.26–2.47
Admission period	0.379			—		
1998–2005		1				
2006–2011	0.173	2.45	0.68–8.91			
2012–2017	0.215	2.24	0.63–8.04			
Age, years	<0.001	1.09	1.06–1.14	—		
Sex	0.661			—		
Male		1				
Female	0.703	1.19	0.48–3.02			
Neurological level	0.157			—		
C1-C4		1				
C5-C8	0.377	0.68	0.29–1.61			
T1-T6	0.058	0.29	0.08–1.04			
AIS grade	0.222			—		
A		1				
B	0.500	1.42	0.51–3.95			
C	0.130	0.32	0.07–1.40			
D	0.273	0.44	0.09–1.92			
AIS motor score	0.041	0.98	0.96–0.99	0.030	0.97	0.95–0.99
CCI	0.007	1.27	1.07–1.51	0.967	0.99	0.71–1.38
APACHE II score at admission	<0.001	1.17	1.10–1.24	0.001	1.18	1.07–1.30
SOFA score on day 0	0.003	1.21	1.07–1.38	0.430	0.92	0.74–1.14
GCS score at admission	0.052	0.91	0.83–1.00			
ISS	0.960	0.99	0.97–1.03			
SOFA score on day 4	0.004	1.26	1.08–1.48			
GCS score at discharge	<0.001	0.71	0.59–0.84	0.158	0.73	0.47–1.13
Fluid balance on day 4, L	0.156	1.08	0.97–1.21			
IMV	0.197	2.59	0.61–11.02			
Duration of IMV, days	0.005	1.01	1.00–1.01			

HR, hazard ratio; CI, confidence interval; ICU, intensive care unit; AIS, American Spinal Injury Association Impairment Scale; CCI, Charlson Comorbidity Index; APACHE, Acute Physiology and Chronic Health Evaluation; SOFA, Sequential Organ Failure Assessment; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; IMV, invasive mechanical ventilation.