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Original article

A Predictive Rule of 30-Day Mortality of Critically Ill Patients after ICU Discharge: A Prospective Observational Study.

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Summary:

Background: Intensive care unit (ICU) survivors have a high and ongoing risk of death after discharge. Aim: To determine the rate and predictors of 30-day post-ICU mortality in critical care survivors to develop a predictive triage model for ICU discharge.

Methods: A prospective observational cohort study included all consecutive survivors admitted to the ICU. Data were collected between January 2014 and December 2015. Outcomes were assessed by telephone interviews at 30 days after ICU discharge. Univariate and multivariate analyses were performed to identify independent factors associated with 30-day post-ICU mortality used to develop a predictive triage model.

Results: Among 573 ICU-admitted patients, 215 discharged survivors were included. Thirty-four (16%) died within the first month. At ICU admission, patients had, WHO performance status > 3, 72(33.5%), severe acute respiratory failure 130(60.5%), invasive mechanical ventilation, 111(51.6). Mean length of stay, 8.5±9.7days. Multivariate regression analysis identified, (OR, 95%CI, p): SAPS II ≥30, (3.258 [1.1-9.6], <0.032), tachycardia at discharge (heart rate≥90b/mn) (3.024 [1.01- 9.11], <0.049), decline in functional handicap status (15.868 [15.18- 48.56], <0.000), and WHO performance status ≥3 (6.57 [2.03- 21.25], <0.002), as independent risk factors of 30-day post-ICU mortality. AUC/ ROC curve of the predictive triage model, 0.914 (95%CI, [0.86-0.96]).

Conclusion: The present study revealed a high rate of mortality among ICU survivors at 30-day post-ICU discharge. A predictive triage model including the severity at ICU admission, performance status at ICU discharge, decline of physiological reserve, and persistent tachycardia demonstrated good discriminative properties to identify patients at risk of 30-day post-ICU mortality.

Keywords: Intensive Care; Mortality; Post-ICU; Outcome; Patient Discharge

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1. Introduction

In the management of the critically ill, the primary focus of intensive care units (ICUs) has traditionally revolved around administering life-sustaining interventions to critically ill patients, with a pivotal challenge being the reduction of ICU mortality rates [1]. Despite this, the attention devoted to outcomes extending beyond the point of ICU discharge has been notably limited [2]. The landscape of post-ICU healthcare grapples with an inherent imbalance between the depth of medical knowledge and the practical constraints of technological capabilities, culminating in a compromise to the quality of medical follow-up [3]. This disparity is particularly pronounced in low and middle-income countries [4], where the scarcity of post-ICU recovery clinics and rehabilitation centers underscores the strain on the healthcare system.

Numerous investigations have underscored a disconcerting reality: survivors of the ICU exhibit elevated in-hospital and post-hospital mortality rates that endure even across extended time frames [5–9].

In recent times, assessing post-ICU survival rates and health-related quality of life has become a pivotal alternate marker for gauging the efficacy of intensive care interventions [10].

However, despite a substantial body of research, there remains a conspicuous lack of clarity surrounding the short-term outcomes of critically ill patients, and the determinants that underpin these outcomes remain elusive. Insight into the landscape of critical care aftermath holds profound potential to influence the decision-making process at the juncture of ICU discharge, thereby empowering caregivers to adopt strategies that mitigate post-ICU mortality risks [11].

Therefore, we aimed to determine the 30-day post-ICU mortality rate and its predictors in critically ill survivors after ICU discharge to develop a predictive triage model for discharge that facilitates discerning individuals at heightened risk of 30-day post-ICU mortality, thus paving the way for informed and targeted interventions at the point of ICU discharge.

The choice of a 30-day mortality endpoint was deliberate because mortality within this period is most often a direct consequence of the initial illness, unresolved issues at the time of discharge, or early complications. These are the deaths most likely to be preventable through effective ICU treatment and a robust discharge plan. The 30-day mark provides a focused measure of the acute phase of recovery and the effectiveness of immediate interventions.

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2. Patients and methods

Study design and settings

This prospective observational cohort study was conducted between January 2014 and December 2015 in a 7-bed medical Intensive Care Unit (ICU) in a University hospital.

Eligibility criteria

The study encompassed all patients admitted to the ICU. To mitigate selection bias, consecutive sampling was implemented, incorporating all eligible patients admitted during the stipulated recruitment period. Exclusions included patients for whom life-sustaining care was limited. Patients were also secondarily excluded if they were unsuitable for reliable follow-up due to incorrect or unanswered phone numbers. The analysis focused exclusively on patients who were discharged alive from the ICU during the study period. The study adheres to the STROBE criteria [12] (Supplementary Material S1).

Ethics

This study received approval from the Research and Ethics Committee of the University Hospital. The need for a written informed consent was waived.

Data collection

All data were recorded prospectively by interviewing the physician in charge of the patients and by reviewing the medical charts. There were no missing data.

Data at ICU admission

Upon ICU admission, comprehensive data were collected, including basic demographic information, past medical history, comorbidities (eg: diabetes mellitus, arterial hypertension, chronic respiratory disease, heart disease, renal disease, malignancy and immunosuppression), chronic disease burden according to (Charlson comorbidity index [13], assessment of baseline World Health Organization (WHO) performance status [14], assessment of baseline functional handicap status), diagnosis at ICU admission, severity of illness at ICU admission evaluated by the Simplified Acute Physiological Score (SAPS) II [15]. A reduced physiological reserve was retained when the WHO performance status was < 2.

The following details of ICU course were recorded for each patient: therapeutic interventions within the ICU (type of ventilatory support, hemodynamic support with inotropic agents or vasopressors at any dose, renal replacement therapy, duration of invasive mechanical ventilation (IMV), and tracheotomy. We also assessed complications of ICU stay: ICU-acquired healthcare-associated infections (mainly ventilator-associated pneumonia and central line-associated bloodstream infection), occurrence of shock, arrhythmias, acute kidney injury, and difficulty of weaning from IMV. Outcome data recorded consisted of ICU length of stay, mortality, and ventilator-free days (VFD).

When a patient's physiological status became stabilized, the decision to discharge from the ICU was made by the medical staff, which consisted of two senior physicians, seven critical care residents, and four fellows.

Data at ICU discharge

Twenty-four hours before discharge, the following data were collected:

- Clinical parameters: Glasgow coma scale, temperature, and hemodynamic and respiratory parameters (systolic and diastolic blood pressure, heart rate, urinary output, respiratory rate, and oxygen saturation). Tachycardia was retained in front of a heart rate ≥90 bpm.
- Routine biological assessment including renal function tests, arterial blood gas, and serum electrolytes.
- Assessment of the WHO performance status at discharge, reassessment of functional handicap status, and use or not of home mechanical ventilation. Functional handicap status was assessed by a local scale at baseline, ICU discharge, and decline by a scale ranging from 0 to 4 (Supplementary Material S2).
- Orientation at ICU discharge: home or transfer to a medical ward. In case of discharge to a medical ward, the treating physician was contacted to assess the patient's outcome.

Follow-up data

Follow-up was performed by a single intensivist well-trained in data collection and handling, who contacted by telephone all survivors or their relatives at 30 days after discharge to assess the patient's vital status (alive or deceased).

Cardiac arrest was classified as the cause of death when no specific underlying cause could be identified from information provided by the family.

In case of failure to contact the patient or their relatives starting from day 30 and after 5 phone calls throughout one month, the patient was secondarily excluded from the study.

Statistical analysis

Patient characteristics were described as frequencies and percentages for categorical variables, means, standard deviation, and 95% confidence interval (CI) for normal continuous variables and medians and interquartile ranges for non-normal continuous variables. Data distribution was assessed using the Shapiro-Wilk test and histogram analysis. Chi-square or Fisher's exact test was used to compare categorical variables, and Student's t test or Mann-Whitney U test to compare continuous variables. The Kaplan-Meier method was used to plot a crude one-month survival curve, and groups were compared using the log-rank test.

Logistic regression was used to determine independent predictors of 30-day post-ICU mortality. First, univariate logistic regression was performed. Then, variables with a significant influence on 30-day mortality ($p < 0.05$) after discharge from the ICU were selected for the multivariable logistic regression model. A predictive triage model for discharge to identify patients at risk of dying within 30 days after ICU discharge was developed. The predictive rule was developed around the items that had been identified as predictors of 30-day post-ICU mortality and were weighted by their respective odds ratios (OR), rounded to their integers. Discrimination of the model was assessed by the area under the receiver operating characteristic (ROC)

curve. A p-value less than 0.05 was considered statistically significant. Statistical analyses were performed with SPSS software.

3. Results

Five hundred and seventy-three patients were admitted to the ICU during the inclusion period. Three hundred and twenty-five (56.7%) were discharged alive. One hundred and ten patients (33.8%) were secondarily excluded due to unreliable follow-up (incorrect phone number and unanswered phone calls), leaving 215(66.1%) patients for the final study analysis. The flowchart of ICU patients' eligibility for 30-day post-ICU mortality analysis is displayed in Fig. 1.

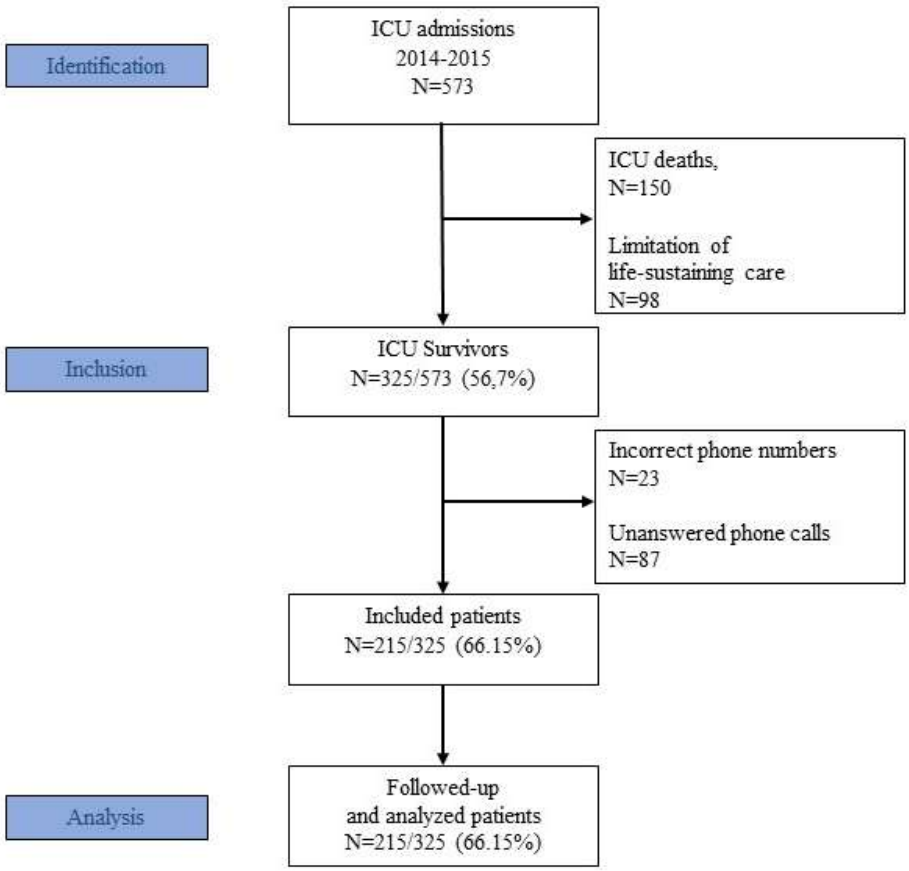

Fig. 1. Flowchart of ICU patients' eligibility for 30-day post-ICU mortality analysis.

Patients' characteristics

Demographic data, comorbidities, and characteristics at ICU admission, as well as details regarding their ICU treatment course, are summarized in Table 1. At ICU admission, patients were mostly male, and over a third had restricted activities at ICU admission (WHO performance status > 3).

The most frequent diagnosis was an acute respiratory failure, with rather severe presentation attested by a mean SAPS II, 29.05±11.2; need for IMV, 111(51.6%), and for vasopressors/inotropic agents, 81(37.7%). Mean length of stay, 8.5±9.7 days. Many developed severe complications, acute kidney injury, 72(33.5%); shock, 59(27.4%) and healthcare-associated infection, 45(20.9%). Characteristics of ICU survivors 24 hours before discharge are detailed in Table 1. At 24 hours before ICU discharge,

83.1% of patients had a reduced physiological reserve, and the handicap was severe for 61.9%.

30-day post-ICU mortality in critically ill survivors

During the first month of ICU discharge, overall 30-day post-ICU mortality was 34 (16%), in-hospital post-ICU mortality was 17/129 (13.2%), and at-home mortality, 17/86 (19.7%). The causes of death are presented in Table 2. The Kaplan-Meier survival curve at 30 days after ICU discharge is displayed in Fig. 2.

Predictors associated with 30-day post-ICU mortality

Compared demographic, clinical characteristics, and outcomes of ICU survivors stratified by survival at 30-day post-ICU are detailed in Table 1. Multivariate regression analysis identified the following independent risk factors of 30-day post-ICU mortality, (OR, 95%CI, p): SAPS II ≥30, (3.258 [1.1-9.6], <0.032), tachycardia at discharge (heart rate≥90b/mn) (3.024 [1.01- 9.11], <0.049), the decline in functional handicap status (15.868 [15.18- 48.56], <0.000), and WHO performance status ≥3 (6.57 [2.03- 21.25], <0.002). These results are shown in Table 3.

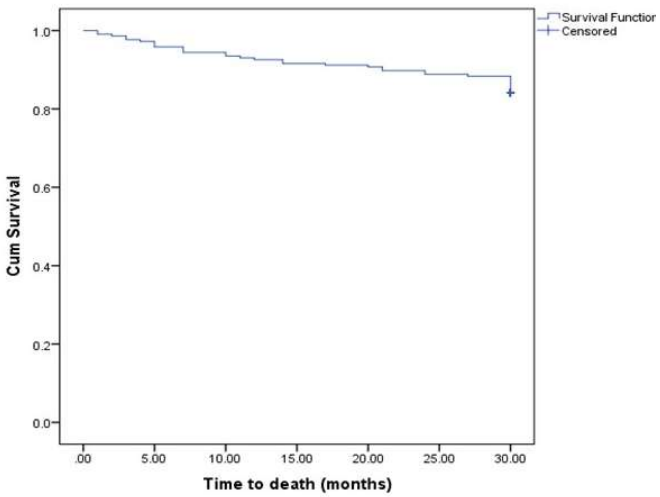

Fig. 2. Thirty-day post-ICU Kaplan-Meier survival curve in critically ill patients after ICU discharge.

Therefore, these four variables were used to develop the model in order to identify patients at risk of 30-day post-ICU mortality. These four items were weighed by their respective OR: SAPS II ≥30, 3 points; tachycardia at discharge, 3 points; decline in functional handicap status, 16 points; and WHO performance status ≥3, 6 points (the total ranging from 0 to 28) (Table 4). The area under the ROC curve value of this predictive model obtained from the development cohort was 0.914 (95%CI, [0.86-0.96]), providing good discriminative properties. The cut-off of 7.5 points has both good sensitivity and specificity, respectively at 93.3% and 82%. (Figure 3).

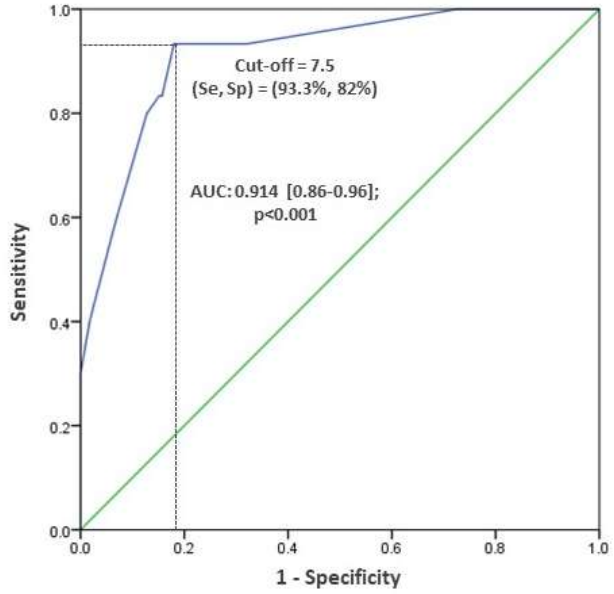

Fig. 3. Receiver operator characteristic curve (ROC) for the prediction of 30-day post-ICU mortality in critically ill patients after ICU discharge. AUC, 0.914; 95%CI, [0.86-0.96].

5. Discussion

The findings of this study provide significant insights into post-ICU mortality within the first 30 days after discharge. It revealed a high rate of mortality among ICU survivors at 30-day post-ICU discharge. A predictive triage model including the severity at ICU admission, along with performance status at ICU discharge, decline of physiological reserve, and persistent tachycardia demonstrated robust discriminative properties to identify patients at elevated risk of 30-day post-ICU mortality.

Study limitations

However, while these findings contribute valuable knowledge, it's essential to acknowledge several limitations inherent to this study. First, the investigation was limited to a medical ICU, which necessitates caution when generalizing results to surgical or mixed ICUs. While the predictive rule's components are independent of patient type, its applicability to surgical patients remains uncertain without specific validation in that population. Second, our reliance on telephone follow-up for determining the cause of death was a limitation, as in-person visits would have provided more robust data. However, during the study period, logistical constraints and the absence of outpatient consultation infrastructure made in-person 30-day follow-up infeasible. We mitigated this by having a single, well-trained intensivist conduct all telephone follow-ups to maximize data accuracy. Third, the exclusion of 33.8% of eligible patients lost to follow-up may have introduced a selection bias. It is plausible that these excluded individuals represent a vulnerable subpopulation at higher risk of mortality due to factors like low socioeconomic status or limited access to care. Therefore, the true mortality rate in the entire cohort of survivors could be higher than what we observed. Finally, to ensure the robustness of our findings, external validation and multicentric studies are warranted.

Results interpretation

The observed in-hospital mortality rate after ICU discharge to medical wards was estimated at 13.2%. It is comparable with rates reported in other studies, such as Wallis et al., who estimated this rate at 9% [16] and Parenmark et al. who's study reported a mortality at 16.2% [17]. This rate was estimated at 10% by Azoulay et al. [18] and at 10.3% by Braber et al. [19]. Other studies evaluating in-hospital mortality after ICU discharge showed rates ranging from 7 to 26 % [20–24]. Such patients at high risk of early mortality might require a longer ICU stay or discharge to a transitional care unit rather than general wards.

Sixteen percent of ICU survivors died within the first month of discharge in the current study. Yen Fu Luo et al. reported a 30-day mortality rate at discharge of 3.4% [25]. These differences have several possible explanations. First, the high demand for ICU admission leads to potential premature discharge. Second, the poor or inadequate health education of ICU survivors and their families. Third, a shortage of access to appropriate post-ICU follow-up in low- and middle-income countries as a result of a substantial gap between the extensive medical expertise and the limited technical capabilities, along with a paucity of rehabilitation establishments and ICU recovery centers [3].

The major cause of death in the present study was acute respiratory failure, followed by septic shock and cardiac arrest. This is consistent with the findings of Lee J et al. [26], who found the main cause of death after ICU discharge to be acute respiratory failure in 56 % of cases, followed by severe sepsis and cardiac arrest in 25% of post-ICU deaths.

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Independent predictors of 30-day post-ICU mortality were SAPS II ≥30, tachycardia at discharge, WHO performance status, and decline in functional handicap status. Unlike findings in other studies [19,31–33], we noted that age was not associated with worse outcomes in the current cohort. Severity on admission evaluated by SAPS II is an independent prognostic factor for 30-day post-ICU mortality in this study. This is in line with results of previous studies [2,18,22,34–36] which showed that severity scores (Acute Physiology and Chronic Health Evaluation II, SAPS II, and Sequential Organ Failure Assessment score) on admission were independent prognostic factors of early post-ICU death.

Tachycardia at discharge was another independent prognostic factor of early post-ICU mortality. The findings of the present study align with previous ones [27,37–41], having identified similar results. Tachycardia 24 hours before discharge is a non-specific clinical sign that can signal unresolved critical illness or the development of new pathologies, such as pulmonary embolism or sepsis. Therefore, the presence of tachycardia at discharge should prompt clinicians to thoroughly investigate and rule out these serious diagnoses before the patient is discharged. Grander et al. [37] suggested that pharmacological interventions to control heart rate may beneficially influence early post-ICU mortality.

In agreement with previous reports [42], the WHO performance status was also an independent prognostic factor of early death after ICU discharge. Rydingsward et al. [42] demonstrated in their study that the performance of functional handicap status evaluation at discharge can help caregivers identify ICU survivors at high risk of subsequent adverse events.

The other independent prognostic factor of 30-day post-ICU mortality was the decline in functional handicap status after discharge. Prior studies [42,43] found similar results. ICU survivors often suffer from acquired weakness and physical impairment [42]. Clinicians must ensure that patients as well as their families are well informed about potential risks after ICU discharge.

An attempt was made to develop a predictive model to identify patients at risk of 30-day post-ICU mortality after discharge. This predictive triage model may offer an opportunity for critical care practitioners to identify patients at risk of early post-ICU mortality. Several other reports have tried to develop predictive triage models of 30-day readmission or death after ICU discharge [20,44–46]. These scores (the Sabadell, the Stability and Workload Index for Transfer, and the Minimizing ICU Readmission scores) are more complex to calculate.

The proposed discharge triage model is a simple, comprehensive, non-time-consuming, cost-effective, and non-invasive tool. The present study can be considered among the rare studies that have established a predictive model of 30-day mortality.

Indeed, these results seem to be very interesting, and important clinical implications can be drawn from this study to improve the quality of care.

Future directives to reduce 30-day post-ICU mortality

As we navigate the intricate landscape of post-ICU mortality, promising avenues arise for improving patient outcomes within the critical 30-day period following discharge. The ultimate aim is to identify patients who might benefit from extended ICU stays, transitional care units, or closer monitoring after discharge, thereby optimizing the trajectory of post-ICU recovery [47–49].

Implementation of Early Specialized Consultation

Given the lack of adapted structures such as ICU recovery centers [48,50] or high-dependency units [51], a potential solution is the integration of early specialized consultations by intensivists. Embracing a proactive approach, these consultations would serve as an opportunity for in-depth assessments of patients' conditions immediately upon ICU discharge. By leveraging the expertise of intensivists, it would be possible to not only evaluate the stability of physiological parameters but also to conduct nuanced assessments of potential complications. This would enable the identification of unresolved critical illnesses or developing medical problems, addressing lingering issues that might otherwise go unnoticed and mitigating the risks of early post-ICU mortality [50]. Such a strategy aims to provide timely intervention, allowing for the adjustment of treatment strategies and the implementation of measures to prevent adverse events.

Another important advantage is that early consultations can serve as a platform for patient and family education [52-55].

Table 1. Compared baseline, ICU course and discharge characteristics between survivors and non-survivors.

	All patients (n=215)	Non-Survivors (n=34)	Survivors (n=181)	P
Male	120 (55.8)	19 (55.9)	101 (55.8)	0.99
Age	53±21.5	58±20.6	51.88±21.5	0.12
Charlson comorbidity index	1.9±1.8	2.8±2.1	1.7±1.7	0.001
WHO performance status ≥3	72 (33.5)	10 (29.4)	141 (22.7)	0.39
Comorbidities				
Diabetes	51 (23.7)	12 (35.3)	39 (21.5)	0.08
Hypertension	68 (31.6)	14 (41.2)	54 (29.8)	0.19
Chronic respiratory failure	99 (46)	15 (44.1)	84 (46.4)	0.8
Cancer	10 (4.7)	6 (17.6)	4 (2.2)	0.00
Chronic kidney disease	23 (10.7)	6 (17.6)	15 (8.3)	0.17
Coronary disease	24 (11.2)	4 (11.8)	20 (11)	1
Baseline functional handicap status	1.5±1.5	2.47±1.5	1.63±1.48	0.003
Diagnosis at ICU admission				
Acute respiratory failure	130 (60.5)	21 (61.8)	109 (60.2)	0.86
Shock	11 (5.1)	4 (11.8)	7 (3.9)	0.07
CNS disorder	29 (13.5)	4 (11.8)	25 (13.8)	0.082
Accidental pathology	16 (7.4)	0 (0)	16 (8.8)	0.082
Others	29 (13.5)	5 (14.7)	24 (13.3)	1
SAPS II	29.05±11.2	38.85±12.8	27.23±9.8	0.00
Intensive care unit course				
Length of ICU stay days	8.5±9.7	10.6±13.9	8.1±8.7	0.3
Length of stay>14 days	25 (11.6)	7 (20.6%)	18 (9.9%)	0.13
Mechanical ventilation	111 (51.6)	18 (52.9)	93 (51.7)	0.8
Tracheostomy	15 (7)	4 (11.8)	11 (6.1)	0.26
Vasopressors/Inotropes	81 (37.7)	14 (41.2)	67 (37)	0.6
Hemodialysis	7 (3.3)	2 (5.9)	5 (2.8)	0.3
Complications				
Healthcare associated infection	45 (20.9)	9 (26.5)	36 (20)	0.39
Shock	59 (27.4)	9 (26.5)	50 (27.8)	0.87
Difficult weaning	22 (10.2)	4 (11.8)	18 (10)	0.9
Severe Arrhythmias	65 (30.2)	15 (44.1)	50 (27.8)	0.05
Acute kidney injury	72 (33.5)	13 (38.2)	59 (32.8)	0.5
Characteristics at discharge				
Glasgow coma scale	14.82±0.8	14.4±1.8	14.8±0.4	0.17
Temperature (°C)	37.1±0.6	37.3±0.8	37±0.4	0.1
Blood pressure (mmHg)	11.9±1.9	11.8±2	11.9±1.8	0.6
Heart rate (b/mn)	89.4±14.9	98.1±19	87.8±13.5	0.006
Urinary output >1ml/Kg/H	8 (3.7)	3 (9.1)	5 (2.9)	0.08
Oxygen saturation	96±2.8	95±2.8	96.1±2.7	0.03
Arterial blood gas				
pH	7.4±0.06	7.4±0.04	7.4±0.06	0.37
PaCO2	41.6±13.1	40±12.1	41.9±13.3	0.6
PaO2	99.6±47.7	96.9±54	100.1±46.7	0.8
HCO3-	28.7±7.6	28.9±7.6	28.7±7.6	0.89
Requiring Home ventilation	31 (14.4)	4 (11.8)	27 (15)	0.6
WHO performance status	1.2±1.1	2.6±1.1	0.8±1.1	0.000
Decline in functional handicap status	55 (25.6)	27 (81.8)	28 (15.5)	0.000
Routine biological assessment				
Sodium level	137±4.9	135.9±5.26	137±4.8	0.26
Potassium level	3.9±0.7	4±0.6	3.8±0.7	0.5
Creatinine	122.5±130.7	199.7±225	109±102	0.11
Discharge at home n (%)	86 (40)	10 (29.4)	76 (42)	0.1

Dichotomous variables are expressed as n (%). Continuous variables are expressed as ICU, Intensive Care Unit; mean ± SD. WHO, world health organization; CNS, central nervous system; SAPS II, simplified acute physiological score II; ICU, intensive care unit; paCO2, partial pressure of carbon dioxide in arterial blood; paO2, partial pressure of oxygen in arterial blood.

Table 2. Causes of death at day 30 post-ICU discharge based on the families' statements

Causes	Patients
Acute respiratory failure	14 (41.2)
Septic shock	6 (17.6)
Shock, unspecified	4 (11.8)
Cardiac arrest	5 (14.7)
Terminal cancer	1 (2.9)
Acute kidney injury	1 (2.9)
Post-operative complications	2 (5.9)
Miscellaneous	1 (2.9)
Total	34 (100)

Data were expressed as n (%) for categorical variables. Cardiac arrest was classified as the cause of death when no specific underlying cause could be identified from information provided by the family.

Table 3. Multivariable analysis to identify factors independently associated with 30-day mortality after ICU discharge

	OR (95% CI)	**P Value**
SAPS II ≥30	3.258 [1.1-9.6]	0.032
Tachycardia at discharge	3.024 [1.01-9.11]	0.049
WHO performance status	6.57 [2.03-21.25]	0.002
Decline in functional handicap status	15.868 [15.18-48.56]	0.000

OR Odd Ratio, CI Confidence Interval, SAPS II Simplified Acute Physiological Score II, WHO World Health Organization.

Table 4. Post-ICU 30-Day Mortality Risk Scoring Algorithm

Variable	Definition/Criterion	Points Assigned
SAPS II Score	≥30	3
Tachycardia at Discharge	Heart Rate >100 bpm at ICU discharge	3
Decline in Functional Handicap Status	Worsening of pre-ICU functional status to discharge	16
WHO Performance Status	≥3	6
Total Score	(Sum of points from all applicable variables)	0 to 28

This ensures a thorough understanding of potential risks, empowering patients and their families to actively engage in post-ICU recovery, recognize warning signs, and seek timely medical attention when required [48]. In low- and middle-income countries, where access to comprehensive post-ICU follow-up might be limited, these consultations could bridge the knowledge gap [3] and empower patients with information critical to their well-being.

Due to the relatively high 30-day post-ICU mortality reported in this study, our department implemented a post-ICU early consultation strategy. This approach includes a first follow-up at day seven post-discharge, with subsequent regular consultations up to at least 12 months (days 7 and 14, months 1, 3, 6, and 12). This managed to reduce 30-day post-ICU mortality in the following two years (2016-2017) to 4% (unpublished data).

Early specialized consultations with timely interventions and enhanced patient education could emerge as a pivotal strategy to improve the quality of care for ICU survivors. Further research could explore the integration of AI and wearable devices to support this kind of personalized, proactive care.

6. Conclusion

In the present study, severity of illness at ICU admission, physiological reserve and its decline, and tachycardia at ICU discharge were identified as independent predictors of short-term mortality of ICU survivors. Premature discharge due to high demands, lack of ICU beds, and inadequate post-ICU facilities may have contributed to poor short-term outcomes of ICU survivors. The proposed predictive triage model may provide an opportunity for critical care practitioners to identify patients at high risk of early post-ICU mortality and may lead to the improvement of ICU discharge practices.

The present findings on 30-day mortality risk factors provide several targets for intervention, including minimizing inappropriate early discharge, providing intermediate care units, and implementing early specialized consultations that involve both patients and family members.

Declarations

Ethics approval and consent to participate

This study was approved by the Research and Ethics Committee of Farhat Hached University Hospital, Sousse, Tunisia. The need for written informed consent was waived. All procedures performed in this study, which involved human participants, were in accordance with the ethical standards of the National Research Committee, as well as with the 1964 Helsinki Declaration and its subsequent amendments or comparable ethical standards.

Consent for publication

All authors consented to the publication of the article.

Availability of data and materials

The datasets used and/or analyzed during the study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

IBS, RT, and MB contributed substantially to drafting the article and revising it critically for intellectual content. All authors read and approved the final manuscript. In preparing this work, Artificial Intelligence was used by the authors solely for language refinement to improve clarity and coherence. The tool did not generate new content or alter the scientific meaning. The authors reviewed and edited the text and are fully responsible for the publication's content.

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Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to limitations of ethical approval involving the participants' data and anonymity but are available from the corresponding author on reasonable request.

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