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ORIGINAL RESEARCH

Status and Risk Factors in Patients Requiring Unplanned Intensive Care Unit Readmission Within 48 Hours: A Retrospective Propensity-Matched Study in China

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Aim: This study investigated the current status and related risk factors of 48-hour unplanned return to the intensive care unit (ICU) to reduce the return rate and improve the quality of critical care management.

Methods: Data were collected from 2365 patients discharged from the comprehensive ICU. Multivariate and 1:1 propensity score matching analyses were performed.

Results: Forty patients (1.69%) had unplanned readmission to the ICU within 48 hours after transfer. The primary reason for return was respiratory failure (16 patients, 40%). Furthermore, respiratory failure (odds ratio [OR] = 5.994, $p = 0.02$) and the number of organ failures (OR = 5.679, $p = 0.006$) were independent risk factors for unplanned ICU readmission. Receiver operating characteristic curves were drawn for the predictive value of the number of organ injuries during a patient's unplanned transfer to the ICU (area under the curve [AUC] = 0.744, sensitivity = 60%, specificity = 77.5%).

Conclusion: The reason for patient transfer and the number of organ injuries during the process were independent risk factors for patients who were critically ill. The number of organs damaged had a predictive value on whether the patient would return to the ICU within 48 hours.

Keywords: risk factors, 48-hour unplanned readmission, comprehensive ICU, propensity-matched study, respiratory failure

Background

A hospital's intensive care unit (ICU) focuses on treating critically ill patients. After stabilising the patient's condition, they are transferred to the relevant hospital department to continue treatment. Unplanned ICU readmission is when a patient is readmitted to the ICU for treatment during the same hospitalisation for various reasons, such as a short-duration aggravated condition. Studies have shown that patients returning to the ICU have a worse prognosis, with increased hospital fatality rates, significantly longer hospital stays, and increased medical and financial burdens.[1–4] A study in the US showed that up to 14% of all ICU discharges could be readmitted.[5] Presently, unplanned readmission to the ICU within 48 hours is used as a sensitive indicator of clinical medical quality.[6]

A retrospective review of readmission studies showed that at least 10% of all readmissions were preventable.[7] Therefore, research on and discoveries of the risk factors for unplanned return to the ICU can promote further actions to reduce return incidences. Patient disease severity is important in predicting unplanned ICU readmission.[6] The current tools to measure patient severity are mainly the acute physiology and chronic health evaluation (APACHE II) and sequential organ failure assessment (SOFA). However, studies have not yet reached a unified conclusion on the risk

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factors of unplanned ICU readmissions.[6,8–11] In addition, limited studies have examined unplanned ICU readmittance within 48 hours.

Since ICU readmissions correlate with complex and severe illnesses, readmission rates require case-mix adjustment before they can be adequately interpreted as quality measures. Therefore, this study investigated the current status and related risk factors of a 48-hour unplanned return to the ICU. In addition, a 1:1 propensity score matching (PSM) analysis was used to align the baseline characteristics of patients with unintended transfers back to the ICU to eliminate any confounding factors.

Methods

Study Design and Patients

We conducted a retrospective cohort study of unplanned ICU (43 beds) readmissions in XX Medical University in China from January 2016 to December 2019. Informed consent was obtained either from the patient or by proxy. The study protocol was approved by an institutional research ethics committee (approval number: 2022KS021). This research did not receive specific grants from funding agencies in public, commercial or not-for-profit sectors.

Readmission was defined as discharge to an area that provided lower levels of care followed by a return to the same or different ICU during the same hospital stay. We excluded patients readmitted for emergency surgery after ICU discharge.

The ICU 48-hour readmission rates = number of readmissions within 48 hours/number of patients discharged alive and eligible for unit readmission during the same hospitalisation cycle × 100%.

Data Collection and Variables

Data were obtained via a retrospective investigation of the hospital's comprehensive ICU patient entry and exit registration forms, electronic medical records, nursing documents and medical records management systems. Data were double-checked and input into Microsoft Excel.

Through a literature search,[1,8,9,11] consultation with critical care medicine specialists and panel discussions, we designed a form to collect data that included:

1. The patient's general condition, age, gender, underlying disease, transfer to the department, etc.
2. The reason for the transfer to the ICU, whether they had surgery, any medical history, vital signs when transferred to the ICU, oxygen saturation (SPO_2) in the ICU and the APACHE II and SOFA scores within the first 24 hours.
3. The vital signs, SPO_2 and the APACHE II and SOFA scores when transferred out of the ICU.

Statistical Analysis

SPSS (Statistical Software Version 25.0, IBM SPSS Statistics, IL, USA) was used for data analysis. Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range) based on the data distribution. Frequency and percentage were used for categorical variables. Potential differences of continuous variables between patients with or without ICU readmission were compared using two independent sample *t*-tests or Wilcoxon signed-rank test. The efficiency of the prediction model by discrimination (concordance index [C-index]) and calibration (Hosmer–Lemeshow goodness-of-fit test [HL test]) was also assessed. A 1:1 (Propensity Score Matching [PSM]) analysis with a calliper width of 0.005 of the SD was conducted to reduce potential selection bias between patients with or without ICU readmission.[12,13] All variables significantly associated with ICU readmission in the univariate analysis were included in a multivariable logistic regression model. A *p*-value of less than 0.05 ($p < 0.05$) was considered statistically significant.

Results

There were 2500 patients admitted to the ICU during the study period (Figure 1). Among them, 135 patients were excluded either due to death (n = 31) or discharge (n = 84) from the ICU, transfer for emergency surgery (n = 16),

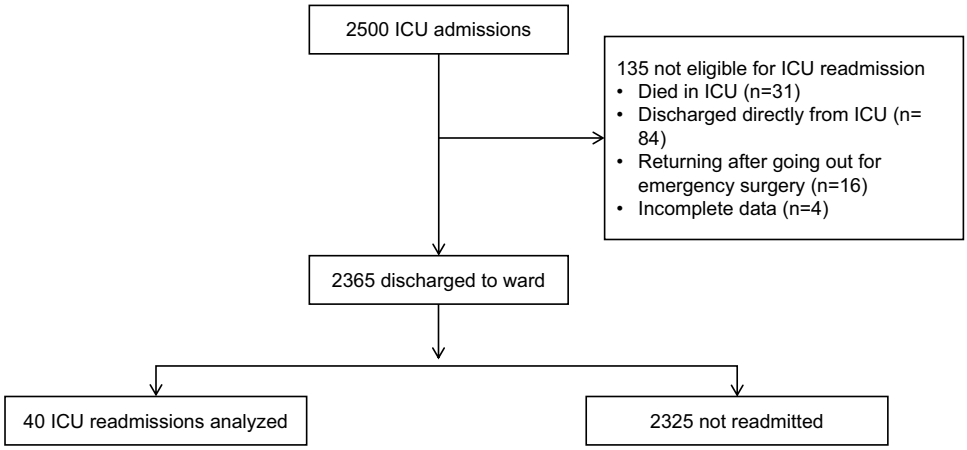

Figure 1 Patient flowchart.

or without complete data (n = 4). Therefore, 2365 patients from the hospital's general wards were included. Among them, 40 (1.69%) patients who were readmitted to the ICU within 48 hours of transfer were included in the final analysis.

To balance all baseline characteristics, eliminate the confounding factors, and further reduce selection bias, this study matched 40 patients who did not return to the ICU by a 1:1 PSM. The matched items included age, gender, medical history, surgical history, and the SOFA and APACHE II scores when they first entered the ICU (Table 1).

Patient Characteristics and Status

The characteristics of the patients readmitted to the ICU are shown in Table 2. The median age was 69 ± 12 years, and the distribution was roughly equal between male and female patients (22 vs 18). Of these 40 patients, 75% (n = 30) suffered from one or more chronic health conditions. More than half of the patients had undergone surgery (72.5% vs 27.5%). Organ failure was prevalent in all patients, and the median of organ failure was 2 (1, 3). In addition, the patients had APACHE II and SOFA median scores of 16 (13, 20) and (6.05 ± 3.59), respectively, when they were first admitted to the ICU.

Table 1 Patient Demographic Characteristics After 1:1 PSM

Patient Characteristics[a]	Readmission (n = 40)	No Readmission (n = 40/2325)	*P* value[b]
Age, years	69.53±12.58	70.58±11.74	0.674
Gender, n (%)			0.654
Male	22 (55%)	20 (50%)	
Female	18 (45%)	20 (50%)	
Admission vital signs			
T, °C	36.29 ± 1.05	36.20 ± 0.86	0.694
HR, times/min	88.78 ± 29.16	87.5 ± 27.66	0.841
R, times/min	19 (15, 25)	19.5 (15, 23.5)	0.719
SPO_2, %	99 (94.5, 100)	94 (92, 97)	0.151
SBP, mmHg	131.1 ± 28.32	136.93 ± 24.19	0.328
MAP, mmHg	91.85 ± 18.52	95.93 ± 15.59	0.290
DBP, mmHg	72.73 ± 16.41	75.48 ± 13.77	0.419

Notes: [a]Continuous data are shown as mean ± standard deviation and categoric data as number (%). [b]Statistically significant (P <0.05).
Abbreviations: T, temperature; HR, heart rate; R, respiration; SPO_2, Pulse oxygen saturation; SBP, systolic blood pressure; MAP, mean arterial pressure; DBP, diastolic blood pressure; PSM, Propensity score matching.

Table 2 Univariate Analysis of Patients with Unplanned Readmission to ICU Within 48 Hours and Without Readmission After 1:1 PSM

Characteristics[a]	Readmission (n = 40)	No Readmission (n = 40)	*P* value[b]
One or more chronic health conditions			0.592
Yes	30 (75%)	32 (80%)	
No	10 (25%)	8 (20%)	
Received surgery			0.799
Yes	29 (72.5%)	30 (75%)	
No	11 (27.5%)	10 (25%)	
Reasons of admission to ICU			<0.001
Survive the perioperative period safely	4 (10%)	22 (55%)	
Respiratory failure	16 (40%)	9 (22.5%)	
Circulatory failure	5 (12.5%)	2 (5%)	
Others	15 (37.5%)	7 (17.5%)	
Numbers of organ failure	2 (1, 3)	1 (1, 1)	<0.001
APACH II scores at first ICU admission	16 (13, 20)	13.5 (10, 21)	0.106
SOFA score at first ICU admission	6.05 ± 3.59	5.33 ± 3.92	0.391
Vital signs at first ICU discharge			
T	36.93 ± 0.73	36.90 ± 0.61	0.829
HR	83.83 ± 14.25	90.70 ± 17.15	0.055
R	21 (18.5, 24)	19.5 (18, 21)	0.04
SPO_2	98.5 (96, 100)	99 (97, 100)	0.878
SBP (mmHg, $\bar{X} \pm s$)	127.08 ± 18.16	120.8 ± 20.34	0.151
MAP (mmHg, $\bar{X} \pm s$)	85.23 ± 11.50	85.10 ± 14.53	0.966
DBP (mmHg, $\bar{X} \pm s$)	64.80 ± 11.21	67.28 ± 14.30	0.392
APACH II	7 (5.5, 10.5)	8 (5, 12)	0.546
SOFA	1 (0, 2)	0 (0, 5)	0.012
ΔAPACH II	7 (5.5, 10.5)	8 (5, 12)	0.543
ΔSOFA	4 (2.5, 7)	5 (2.5, 7.5)	0.954

Notes: [a]Continuous data are shown as mean ± standard deviation and categoric data as number (%). [b]Statistically significant (P <0.05).
Abbreviations: T, temperature; HR, heart rate; R, respiration; SPO_2, Pulse oxygen saturation; SBP, systolic blood pressure; MAP, mean arterial pressure; DBP diastolic blood pressure; APACH II, acute physiology and chronic health evaluation; PSM, Propensity score matching; ICU, Intensive care unit; SOFA, sequential organ failure assessment.

Causes for ICU Readmission

The most common reason for ICU readmission was postoperative respiratory failure, observed in 16 patients (40%), followed by circulatory failure in five patients (12.5%). Other causes included perioperative period (n = 4, 10%), renal dysfunction (n = 3, 7.5%), delirium (n = 3, 7.5%), gastrointestinal disease (n = 3, 7.5%), neurological disease (n = 3, 7.5%) and sepsis (n = 3, 7.5%) (Figure 2).

Risk Factors for ICU Readmission

Univariate analysis found four variables that were significantly associated with ICU readmission, namely the reason for admission ($p < 0.001$), number of associated organ injuries (2 [1, 3] vs 1 [1, 1], $p < 0.001$), respiratory rate (R) and SOFA scores at first discharge between patients with and without ICU readmissions, R of 21 (18, 24) vs 19 (18, 21), $p = 0.04$ and SOFA of 1 (0, 2) vs 0 (0, 5), $p = 0.012$) (Table 2).

Considering these variables in the analytical model in logistic regression analysis, admissions for respiratory failure (odds ratio [OR] = 5.994, 95% confidence level [CI] = 1.319–27.242, $p = 0$ 0.02) and number of organ injuries (OR = 3.022, 95% CI = 1.368–6.678, $p = 0.006$) were independent risk factors for ICU readmission (Table 3).

In addition, we plotted the receiver operating characteristic curve (ROC curve) of the number of organs damaged during patient transfer to the predictive value of unplanned return to the ICU within 48 hours and calculated the AUC (AUC = 0.744, sensitivity = 60% and specificity = 77.5%) (Figure 3).

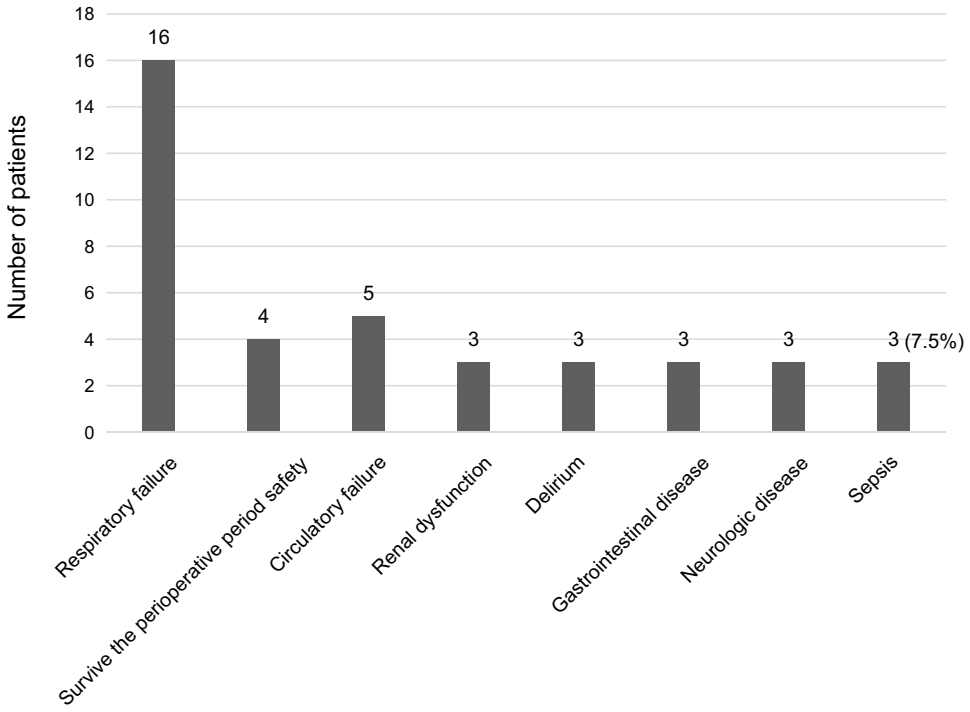

Figure 2 Reasons for intensive care unit readmission.

Discussion

To the best of our knowledge, this is the first retrospective observational study on patients' unplanned readmission to the ICU within 48 hours via a 1:1 PSM analysis. Results showed that the 48-hour ICU readmission rate was 1.69%, which was at a low level globally (2.4% to 9.6%).[8,11,14,15] Previous studies showed that unplanned readmissions were associated with more extended hospital stays and higher mortality. Therefore, it is necessary to consider unplanned readmissions to ICU as a sensitive indicator of the quality of care management. Compilations should be done quarterly, and comparisons should be made to identify problems promptly.

Risk Factors

We used propensity matching to control for all variables that affected the risk of readmission, such as basic patient information (age, gender, medical history and surgery), reasons for transfer, vital signs at transfer, and the SOFA and APACHE II scores.

Table 3 Multivariable Logistic Regression Analysis of Potential Risk Factors of ICU Readmission

Risk Factors	B	SE	Wald	P[a]	OR	95% CI
Admission reasons			8.835	0.032		
Respiratory failure	1.791	0.772	5.375	0.02	5.994	1.319–27.242
Circulatory failure	1.736	1.171	2.197	0.138	5.672	0.572–56.285
Others	2.196	0.769	8.148	0.004	8.992	1.99–40.625
Numbers of organ failure	1.106	0.404	7.478	0.006	3.022	1.368–6.678
R at first ICU discharge	0.044	0.069	0.4	0.527	1.044	0.913–1.195
SOFA scores at first ICU discharge	−0.188	0.103	3.311	0.069	0.829	0.677–1.015

Notes: [a]Statistically significant (P <0.05). B value refers to the regression coefficient and intercepts (constant term).
Abbreviations: SE, standard error; Wald, Wald test; OR, odds ratio; CI, confidence interval; ICU, Intensive care unit; R, respiration.

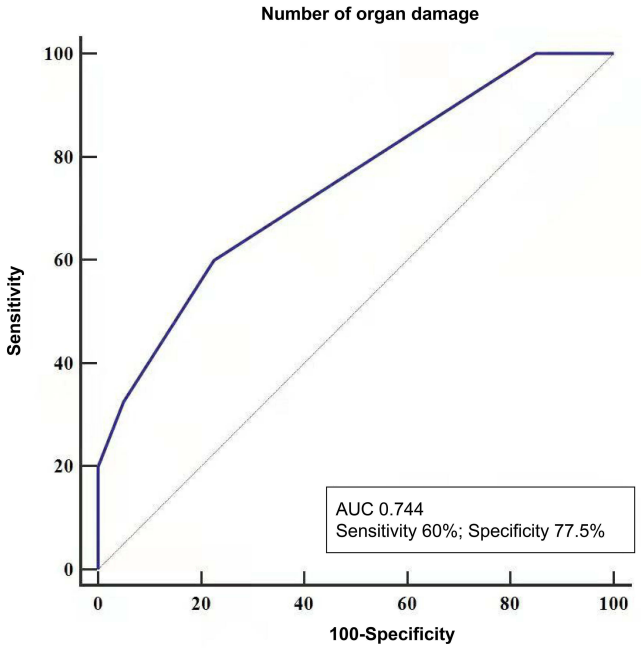

Figure 3 ROC curve.

Transfer Reasons

Our study found that the reason for ICU readmission within 48 hours was an independent risk factor. We divided the reasons for transfer into three major categories, namely respiratory and circulatory failures and others (such as bleeding, infection, etc.), and performed subgroup analyses. The results showed that respiratory failure was the leading cause of unplanned transfer (n = 16). This result was consistent with those of previous studies.[1,15–19]

The incomplete resolution of respiratory diseases remains a significant cause of potentially preventable ICU readmissions.[19] Attention to sputum volume before ICU discharge may prevent unexpected readmissions. Applying nurse-led pulmonary physical therapy can effectively improve patient outcomes.[20] In addition, general wards do not pay enough attention to patients' respiratory status or lack of ability to predict changes in a patient's condition, which may lead to unplanned transfers.

The readmission rate for breathing problems has been reported to range from 18% to 59%;[18] our study's result is 40%, which is on the higher side of the range. In future, we aim to focus on continuous treatment related to pulmonary diseases to enhance patients' pulmonary rehabilitation, including integrating treatment with the general ward after the patient is transferred out of the ICU. Furthermore, family members will be invited to participate in the trinity management model.[6]

SOFA Scores

Most studies showed that SOFA scores at admission or discharge were associated with unplanned patient readmission.[10,21] However, our findings were different and showed that, although patients readmitted had higher SOFA scores compared to those who were not (at first ICU admission 6.05 ± 3.59 vs 5.33 ± 3.92; at first ICU discharge 1 [0, 2] vs 0 [0, 5]), the logistic analysis showed that the SOFA scores had no association with patient readmission. Our findings support a previously reported study that the SOFA scores on discharge were not associated with patient readmissions.[22] However, this finding may be related to the sample size and patient heterogeneity. Hence, further research is required.

Number of Organ Failures

We found that the number of patients with comorbid organ damage on the first admission to the ICU was an independent risk factor for unplanned readmission within 48 hours of transfer. However, limited studies support this finding. Patients admitted to the ICU usually have one or several organ failures, such as respiratory, renal, cerebral, circulatory, hepatic or coagulation disorders. There was a significant difference in respiratory parameters between readmitted and non-readmitted patients at discharge, with a lower PaO2/FiO2 ratio in the readmitted patients.[23–25] Moreover, the respiratory score was considerably greater in readmitted patients when examining the specific SOFA measures. Moreover, respiratory conditions accounted for most of readmissions.[26] As a consequence, respiratory functions seem to be crucial to the probability of ICU readmission, and patients might be released from the hospital with respiratory functions that are not adequately stable There may be a potential ward vulnerability with relation to particular respiratory assistance after critical care and therefore a comprehensive care of these patients is necessary.

A total of 678,960 patients were included in three studies.[27] The different types of organ failures reported in the studies ranged from one to six, and the incidence of organ failure was 7%, 14% and 23%; the in-hospital mortality rate was 5%, 11% and 15%. The number of organ failures represented the patients' severity. However, patients with organ failure can be treated, and organ function can be partially improved, but a complete recovery is a slow process. Therefore, after being transferred out of the ICU, the staff should pay close attention to partly recovered patients.

Limitations

This study had some limitations. First, this was a single-centre study with a limited sample size. After matching, only 40 patients were included in each group, resulting in wide intervals of predictors in univariate and multivariate analyses. Further multicentre studies with large sample sizes are warranted to verify our findings. Second, we only performed propensity matching on the patient's basic information and information provided on admission. Third, the primary aim of this study was to investigate the risk factors and possible outcomes of ICU early readmission.

Conclusion

We identified two potential independent risk factors in this four-year retrospective analysis of 40 unplanned ICU readmissions within 48 hours. Respiratory failure remained the leading cause of readmission. In addition, the number of organs damaged on initial admission was a decisive factor in predicting unplanned readmissions. Hence, healthcare professionals should be concerned when patients have two or more damaged organs when they are first admitted to ICU. However, further randomized clinical trials are necessary to compare the effect of pre-emptive management versus routine care.

Data Sharing Statement

All data generated or analysed during this study are included in this article. Further enquiries can be directed to the corresponding author.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of The Fourth Hospital of Hebei Medical University (approval number: 2022KS021). Written informed consent was obtained from all participants.

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Disclosure

The authors report no conflicts of interest in this work.

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