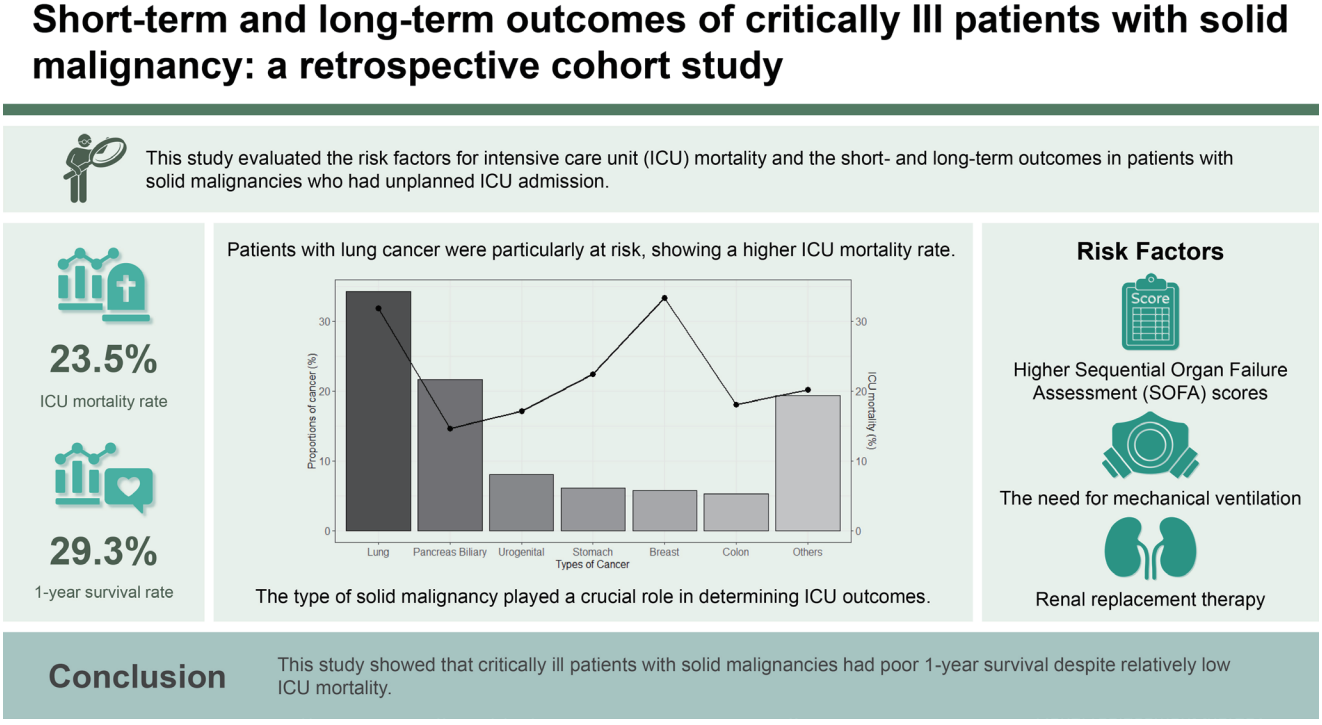
ORIGINAL ARTICLE

Korean J Intern Med 2024;39:957-966
https://doi.org/10.3904/kjim.2024.054

Short-term and long-term outcomes of critically ill patients with solid malignancy: a retrospective cohort study

Su Yeon Lee, Jin Won Huh, Sang-Bum Hong, Chae-Man Lim, and Jee Hwan Ahn

Department of Pulmonary and Critical Care Medicine, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea



Background/Aims: With the global increase in patients with solid malignancies, it is helpful to understand the outcomes of intensive care unit (ICU) admission for these patients. This study evaluated the risk factors for ICU mortality and the short- and long-term outcomes in patients with solid malignancies who had unplanned ICU admission.

Methods: This retrospective cohort study included patients with solid malignancies treated at the medical ICU of a single tertiary center in South Korea between 2016 and 2022.

Results: Among the 955 patients, the ICU mortality rate was 23.5%. Lung cancer was the most common cancer type (34.2%) and was significantly associated with increased ICU mortality (odd ratio [OR] 1.58, $p = 0.030$). Higher Sequential Organ Failure Assessment scores at ICU admission (OR 1.11, $p < 0.001$), the need for mechanical ventilation (OR 6.74, $p < 0.001$), or renal replacement therapy during the ICU stay (OR 2.49, $p < 0.001$) were significantly associated with higher ICU mortality. The 1-year survival rate after ICU admission was 29.3%, with a median survival of 37 days for patients requiring mechanical

pISSN 1226-3303
eISSN 2005-6648
http://www.kjim.org

ventilation, and 23 days for patients requiring renal replacement therapy.
Conclusions: This study showed that critically ill patients with solid malignancies had poor 1-year survival despite relatively low ICU mortality. These findings highlight the need for careful consideration of ICU admission in patients with solid malignancy, and decision-making should be based on an understanding of the expected short- and long-term prognosis of ICU admission after an informed discussion among patients, families, and physicians.

Keywords: Malignant neoplasms; Intensive care unit; Mortality

INTRODUCTION

The global incidence of cancer is increasing [1]. Previous studies indicated that patients with cancer account for approximately 10–15% of all intensive care unit (ICU) admissions, and there is an increasing trend in the number of metastatic cancer cases for ICU admissions [2-5]. The mortality rate of patients with advanced cancer admitted to the ICU was high [6,7]. Therefore, patients with advanced cancer were often considered a disqualifier for ICU admission in the past [8]. However, recent studies have shown a decrease in the mortality rate in patients with cancer admitted to the ICU, and this has been attributed to advances in overall critical care and sepsis management [9-11]. Despite these improvements, the decision to treat cancer patients with limited life expectancy in the ICU, where beds and resources are limited, remains a complex and challenging issue [6,12]. In Korea, there is a paucity of data on the outcomes of critically ill patients with solid malignancies. This study aimed to better understand the risk factors for mortality and the short- and long-term outcomes in patients with solid malignancies who had unplanned ICU admissions.

METHODS

Study design and patients

This single-center retrospective cohort study was conducted at Asan Medical Center, a tertiary hospital in Seoul, Korea. Adult patients with solid malignancies admitted to the medical ICU between January 2016 and December 2022 were included. The inclusion criteria were as follows: (i) adult patients aged > 18 years, (ii) patients who had oncological follow-ups and were on active cancer treatment, (iii) patients admitted to the ICU unexpectedly, (iv) patients treated in the ICU for more than a day or those who died on the day of ICU admission. Patients who spent only one day in the ICU for monitoring or postoperative care were excluded. Only the first ICU admission during the study period per patient was included.

Data collection

We collected the following patient data from electronic medical records: age, sex, height, weight, body mass index (BMI), Eastern cooperative oncology group (ECOG) performance status at hospital admission, underlying cancer types, date of registration in the Korea Central Cancer Registry, dates of hospital and ICU admission and discharge, cancer stages at ICU admission, causes of ICU admission, date of death, date of last follow-up, and history of chemotherapy or radiotherapy within 6 months from the index ICU admission, vasopressor administration doses, received oxygen therapy, FiO_2 at ICU admission, Sequential Organ Failure Assessment (SOFA) score at ICU admission, Glasgow Coma Scale (GCS) score, laboratory measurements including arterial blood gas analysis conducted between 6 h before and 24 hours after ICU admission, use of mechanical ventilation, the new application of renal replacement therapy (RRT), extracorporeal membrane oxygenation during the ICU stay, and date of tracheostomy. Among ICU survivors, whether chemotherapy was restarted after ICU discharge and causes of in-hospital death without ICU re-admission were collected. The time from cancer diagnosis to ICU admission was calculated based on the date of ICU admission and the date of registration in the Korea Central Cancer Registry.

The primary outcome was ICU mortality. The secondary outcomes were 1-year survival rate, risk factors for ICU mortality, and organ support treatments administered during the ICU stay.

Statistical analysis

Variables are represented by means with standard devia-

https://doi.org/10.3904/kjim.2024.054

Table 1. Baseline characteristics according to ICU survival and death

Variable	ICU survivor (n = 731)	ICU non-survivor (n = 224)	Total (n = 955)	*p* value
Age (yr)	64.0 (57.0–71.0)	66.0 (58.0–72.0)	65.0 (57.0–71.0)	0.093
Sex, male	496 (67.9)	149 (66.5)	645 (67.5)	0.771
BMI (kg/m^2)	22.2 ± 3.4	22.6 ± 3.5	22.3 ± 3.4	0.164
Cancer types				< 0.001
Lung	223 (30.5)	104 (46.4)	327 (34.2)	
Pancreatic-biliary	176 (24.1)	30 (13.4)	206 (21.6)	
Urogenital	63 (8.6)	13 (5.8)	76 (8.0)	
Breast	36 (4.9)	18 (8.0)	54 (5.7)	
Others	233 (31.9)	59 (26.3)	292 (30.6)	
Stage				0.115
Localized	34 (4.7)	5 (2.2)	39 (4.1)	
Locally advanced	129 (17.7)	32 (14.3)	161 (16.9)	
Metastatic	568 (77.7)	187 (83.5)	755 (79.1)	
Causes of ICU admission				< 0.001
Respiratory failure	306 (41.9)	135 (60.3)	441 (46.2)	
Shock	244 (33.4)	36 (16.1)	280 (29.3)	
Cardiac arrest	27 (3.7)	24 (10.7)	51 (5.3)	
Altered mental status	37 (5.1)	10 (4.5)	47 (4.9)	
Metabolic acidosis	18 (2.5)	8 (3.6)	26 (2.7)	
Post-operative/procedure	49 (6.7)	3 (1.3)	52 (5.5)	
Others	50 (6.8)	8 (3.6)	58 (6.1)	
Diagnosis to ICU admission (mo)	12.2 (4.2–35.2)	8.6 (3.1–24.9)	11.5 (4.0–31.5)	0.015
Recent chemotherapy	604 (82.6)	192 (85.7)	796 (83.4)	0.326
Recent radiation therapy	127 (17.4)	59 (26.3)	186 (19.5)	0.004
ECOG performance status				0.020
0–1	546 (74.7)	149 (66.5)	695 (72.8)	
2–4	185 (25.3)	75 (33.5)	260 (27.2)	
Admission to ICU transfer, day	0.0 (0.0–2.0)	1.0 (0.0–8.5)	0.0 (0.0–4.0)	< 0.001
ICU admission source				
Emergency room	462 (63.2)	105 (46.9)	567 (59.4)	< 0.001
General ward	269 (36.8)	119 (53.1)	388 (40.6)	< 0.001
Parameters at ICU admission				
FiO_2	0.46 ± 0.23	0.58 ± 0.23	0.49 ± 0.23	< 0.001
PaO_2/FiO_2 < 300	420 (57.5)	168 (75.0)	588 (61.6)	< 0.001
SOFA score	10 (7–13)	13 (11–16)	11 (8–14)	< 0.001
Vasopressors received	498 (68.1)	190 (84.8)	688 (72.0)	< 0.001
Equivalent norepinephrine dose (μg/kg/min)	0.14 ± 0.18	0.21 ± 0.23	0.16 ± 0.19	< 0.001
Laboratory results at ICU admission				
Hemoglobin (g/dL)	9.6 ± 2.0	9.4 ± 2.0	9.6 ± 2.0	0.174
WBC (× 10^3/μL)	12.8 ±10.5	13.8 ±11.7	13.0 ±10.8	0.227

Table 1. Continued

Variable	ICU survivor (n = 731)	ICU non-survivor (n = 224)	Total (n = 955)	*p* value
Platelet (× 10^3/μL)	174 ±117	166 ±120	172 ±117	0.384
BUN (mg/dL)	27.0 ±19.6	33.8 ±22.1	28.6 ±20.4	< 0.001
Creatinine (mg/dL)	1.3 ± 1.2	1.5 ± 1.4	1.3 ± 1.2	0.018
Total bilirubin (mg/dL)	1.62 ± 2.36	1.87 ± 3.93	1.68 ± 2.81	0.382
Prothrombin time (INR)	1.4 ± 0.7	1.6 ± 0.7	1.5 ± 0.7	0.001
Albumin (g/dL)	2.3 ± 0.5	2.2 ± 0.4	2.3 ± 0.5	< 0.001
CRP (mg/dL)	15.0 ± 10.5	14.9 ± 10.2	14.9 ± 10.4	0.961
Lactic acid (mmol/dL)	3.1 ± 3.0	4.0 ± 3.6	3.3 ± 3.2	0.001
Neutropenia	66 (9.0)	27 (12.1)	93 (9.7)	0.227

Values are presented as median (interquartile range), number (%), or mean ± standard deviation.
ICU, intensive care unit; BMI, body mass index; ECOG, Eastern cooperative oncology group; SOFA, Sequential Organ Failure Assessment; WBC, white blood cell; BUN, blood urea nitrogen; CRP, C-reactive protein.

tions or medians with interquartile ranges, depending on their distribution. The included patients were divided into the ICU survivor group and the ICU non-survivor group based on ICU mortality. The baseline and ICU characteristics were compared between the two groups. The student's t-test was used to compare continuous variables. The chi-squared test, or Fisher's exact test, was used for categorical variables. The risk factors for ICU mortality were analyzed by multivariable logistic regression analysis. The variables with *p* values < 0.1 in the univariable analysis, except for those with multicollinearity, were included in the multivariable analysis and backward elimination was conducted. Survival analyses were performed using the Kaplan–Meier method and the log-rank test. All *p* values were two-tailed, and the threshold for statistical significance was set at *p* values < 0.05. All statistical analyses were performed using R version 4.2.1 (R Core Team, Vienna, Austria). Missing values were not imputed.

Ethical approval and informed consent

The study protocol was reviewed and approved by the Institutional Review Board of Asan Medical Center (IRB number: 2023-0922). The ethics review board waived the requirement for informed consent due to the observational nature of this study.

RESULTS

A total of 955 patients with solid malignancies were included. They were followed through July 19, 2023. The baseline characteristics of the patients are described in Table 1. The overall ICU mortality was 23.5%, which significantly differed based on the baseline cancer types (Fig. 1). For all types of solid malignancies, lung cancer was the most frequent type (34.2%) of cancer in our study cohort. Most patients had metastatic cancer (79.1%), and respiratory failure was the most common cause of ICU admission (46.2%), followed by shock (29.3%). The proportion of patients who received chemotherapy within 6 months was 83.4%. The SOFA score at ICU admission was 11. At the time of ICU admission, in 61.6% of the patients, the PaO_2/FiO_2 ratio was lower than 300, and vasopressors were used in 72.0% of patients. When comparing baseline characteristics between the ICU survivor and non-survivor groups, respiratory failure (60.3% vs. 41.9%) and cardiac arrest (10.7% vs. 3.7%) were more common in the non-survivor groups, while shock (33.4% vs. 16.1%) and post-operative/procedure (6.7% vs. 1.3%) were more common in the survivor groups ($p < 0.001$). The median time from cancer diagnosis to ICU admission was shorter (8.6 mo vs. 12.2 mo, $p = 0.015$), and the ECOG performance status was poorer (ECOG performance status 2–4; 33.5% vs. 25.3%, $p = 0.020$) in the non-survivor group. In the ICU non-survivor group, the PaO_2/FiO_2 ratio was lower (240 ± 193 vs. 289 ± 171, $p = 0.001$), higher

https://doi.org/10.3904/kjim.2024.054

doses of vasopressor were administered (0.21 ± 0.23 μg/kg/min vs. 0.14 ± 0.18 μg/kg/min, p <0.001), and the median SOFA score was higher (13 [interquartile range, 11–16] vs. 10 [interquartile range, 7–13], p < 0.001) than the ICU survivor group. The rates of neutropenia were not significantly different between the two groups (12.1% vs. 9.0%, p = 0.227). In lung and breast cancer patients, respiratory failure was the most common reason for ICU admission (67.9% and 64.8%, respectively), whereas in patients with pancreas biliary cancer, shock was the most common reason for ICU admission (Supplementary Table 1, p < 0.001). The missing variables and their number are shown in Supplementary Table 2.

During the ICU stay, 67.7% of the study patients received mechanical ventilation, and the median duration of mechanical ventilation was 6.0 days (3–13 days) (Table 2). RRT was applied in 23.2% of patients, and tracheostomy was performed in 17.4% of patients. The median length of ICU and post-ICU hospital stays was 6.0 days (3–12 days) and 9.0 days (0–19 days), respectively. The hospital mortality rate was 42.1%, and the 1-year mortality rate was 70.3%. The ICU non-survivor group was more likely to receive me-

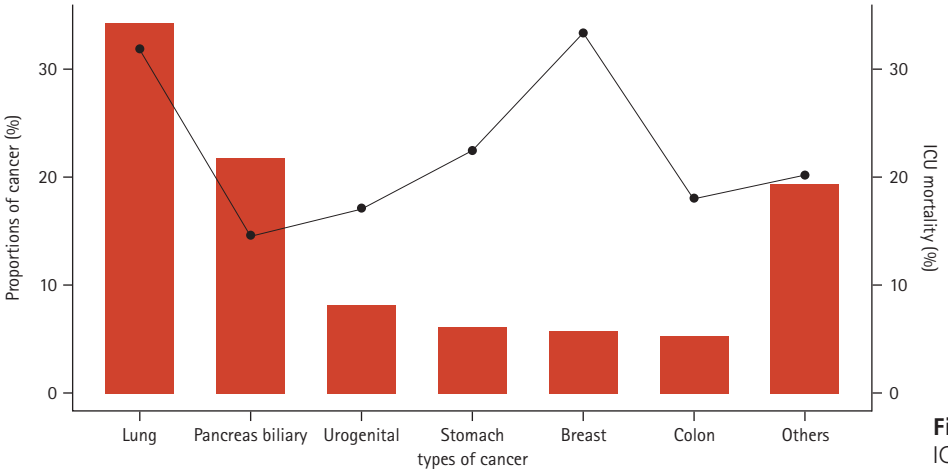


Figure 1. Proportions of cancers and ICU mortality. ICU, intensive care unit.

Table 2. ICU treatment and outcomes

Variable	ICU survivor (n = 731)	ICU non-survivor (n = 224)	Total (n = 955)	p value
ICU treatment				
Mechanical ventilation	433 (59.2)	214 (95.5)	647 (67.7)	< 0.001
Duration of mechanical ventilation (day)	5.0 (3.0–10.0)	9.0 (4.0–18.0)	6.0 (3.0–13.0)	< 0.001
Renal replacement therapy	126 (17.2)	96 (42.9)	222 (23.2)	< 0.001
ECMO	17 (2.3)	9 (4.0)	26 (2.7)	0.260
Tracheostomy	114 (15.6)	52 (23.2)	166 (17.4)	0.011
Length of stay (day)				
ICU	5.0 (3.0–10.0)	10.5 (4.0–18.0)	6.0 (3.0–12.0)	< 0.001
Post ICU	12.0 (6.0–23.0)	0.0 (0.0–0.0)	9.0 (0.0–19.0)	< 0.001
ICU admission to hospital discharge	19 (12.0–33.0)	10.5 (4.0–18.0)	17.0 (10.0–29.0)	< 0.001
ICU readmission	49 (6.7)	0 (0)	49 (5.13)	< 0.001
ICU mortality	0 (0.0)	224 (100.0)	224 (23.5)	< 0.001
Hospital mortality	178 (24.4)	224 (100.0)	402 (42.1)	< 0.001
1-year mortality	447 (61.2)	224 (100.0)	671 (70.3)	< 0.001

Values are presented as number (%) or median (interquartile range).
ICU, intensive care unit; ECMO, extracorporeal membrane oxygenation.

chanical ventilation (95.5% vs. 59.2%, $p < 0.001$) and RRT (42.9% vs. 17.2%, $p < 0.001$), compared to the ICU survivor group.

In multivariable logistic regression analysis (Table 3), lung cancer (odds ratio [OR] 1.58, $p = 0.030$), SOFA score at ICU admission (OR 1.11, $p < 0.001$), mechanical ventilation

Table 3. Risk factors associated with ICU mortality

Variable	Univariate			Multivariate		
	OR	95% CI	*p* value	OR	95% CI	*p* value
Age	1.01	1.00–1.03	0.094			
Others	1			1		
Lung cancer	1.72	1.19–2.51	0.004	1.58	1.05–2.41	0.030
Pancreas-biliary cancer	0.61	0.37–0.99	0.050	0.54	0.30–0.95	0.040
Breast cancer	1.94	1.01–3.62	0.040	1.74	0.84–3.54	0.130
Urogenital cancer	0.79	0.38–1.52	0.500	0.53	0.24–1.12	0.110
Recent radiation therapy	1.70	1.19–2.41	0.003	1.48	0.98–2.22	0.060
ECOG performance status 2–4	1.43	1.03–1.99	0.033			
SOFA score at ICU day 1	1.21	1.17–1.26	< 0.001	1.11	1.05–1.18	< 0.001
ICU admission from the general ward	1.95	1.44–2.64	< 0.001	1.30	0.91–1.84	0.150
Mechanical ventilation	14.7	8.09–30.1	< 0.001	6.74	3.33–15.21	< 0.001
Renal replacement therapy	3.60	2.60–5.00	< 0.001	2.49	1.61–3.86	< 0.001

ICU, intensive care unit; OR, odds ratio; CI, confidence interval; ECOG, Eastern cooperative oncology group; SOFA, Sequential Organ Failure Assessment

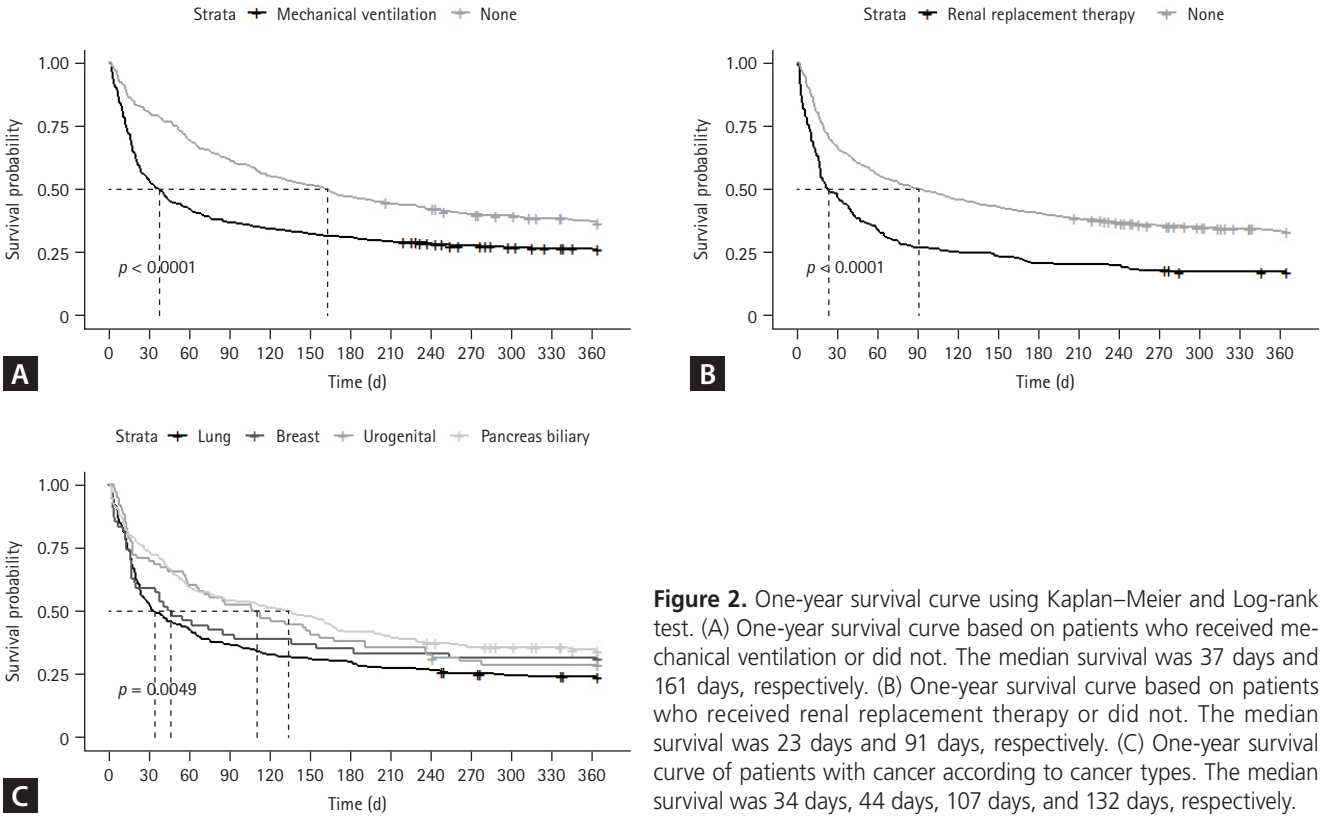


Figure 2. One-year survival curve using Kaplan–Meier and Log-rank test. (A) One-year survival curve based on patients who received mechanical ventilation or did not. The median survival was 37 days and 161 days, respectively. (B) One-year survival curve based on patients who received renal replacement therapy or did not. The median survival was 23 days and 91 days, respectively. (C) One-year survival curve of patients with cancer according to cancer types. The median survival was 34 days, 44 days, 107 days, and 132 days, respectively.

https://doi.org/10.3904/kjim.2024.054

during the ICU stay (OR 6.74, $p < 0.001$), and RRT during the ICU stay (OR 2.49, $p < 0.001$) were independent risk factors for ICU mortality. Pancreas-biliary cancer was associated with lower ICU mortality (OR 0.54, $p = 0.040$). In Supplementary Table 3, compared to those with respiratory failure, patients with shock (OR 0.35, $p < 0.001$) and post-operative/procedure (OR 0.10, $p = 0.001$) had a lower risk of ICU mortality.

When 1-year survival after ICU admission was compared in patients requiring mechanical ventilation or RRT, the survival rates were significantly lower in patients who received mechanical ventilation compared to those who did not receive mechanical ventilation (26.3% vs. 37.4%, $p < 0.0001$), and in patients who received RRT compared to those who did not (17.5% vs. 33.4%, $p < 0.0001$) (Fig. 2A, B). When 1-year survival rates among patients with lung, breast, urogenital, and pancreas biliary cancers were compared, the survival rates were significantly different at 24.1%, 28.8%, 31.5%, and 34.7%, respectively ($p = 0.0049$) (Fig. 2C).

Of the 731 patients who survived in the ICU, 178 (24.4%) died in the hospital. Of these, 141 (79.2%) were not readmitted to the ICU and died in the hospital because the patient or family decided to withhold life-sustaining treatment after experiencing deterioration on the general ward (Supplementary Table 4). Among patients who survived in the ICU, the one-year mortality rate after ICU discharge was 61.2%. Patients with metastatic cancer had the highest one-year mortality (63.8%) compared to those with other stages of cancer ($p = 0.029$, Supplementary Fig. 1A). Among patients with metastatic cancer who survived in the ICU (n = 568), 246 (45.9%) patients received chemotherapy after ICU discharge. Those who received post-ICU chemotherapy had significantly lower one-year mortality than those who did not receive chemotherapy (49.1% vs. 75.1%, $p < 0.0001$), and their median survival was 383 days and 42 days, respectively (Supplementary Fig. 1B). Among ICU survivors, those who received RRT during ICU stay had higher one-year mortality than those who did not receive RRT (69.1% vs. 60.0%, $p = 0.012$) (Supplementary Fig. 2B).

DISCUSSION

In this single-center, retrospective cohort study of critically ill patients with solid malignancy, the ICU mortality was not high, but the 1-year mortality of the cohort was above 70%. The types of underlying cancer and treatments received during the ICU stay were significantly associated with ICU mortality. This is the first study to report the long-term outcomes of critically ill patients with solid malignancies in Korea.

Our study showed ICU and hospital mortality rates of 23.5% and 42.1%, respectively, which are similar to the statistics previously reported from a Korean dataset and a single-cohort study from France, which included patients with solid malignancies. The Korean multi-center data from 2018 showed an ICU mortality rate of 24.6% and a hospital mortality rate of 38.6% [4]. Similarly, a study from France reported an ICU mortality rate of 22.6% [5]. Conversely, our ICU mortality rate was significantly higher than a study on national data from the Netherlands, which reported an ICU mortality rate of 13.6% for solid malignancies [8]. In the Dutch study, the rates of organ failure such as acute renal failure, the need for mechanical ventilation, and the use of vasoactive drugs were reported to be 10.2%, 36.5%, and 36.7%, respectively. In comparison, our study showed that the rates of RRT initiation, mechanical ventilation use, and use of vasopressors were 23.2%, 67.7%, and 72.0%, respectively. In addition, the median SOFA score of the patients at ICU admission was 11, which was higher than the reported study [4,5]. The difference in patient severity observed in our study and the Dutch study findings could indicate a higher baseline severity in our patient cohort. In addition, our study showed that patients who required mechanical ventilation or RRT during their ICU stay had significantly higher ORs for mortality of 6.74 and 2.49, respectively. Our study showed a significant association between a higher SOFA score on ICU admission and an increased risk of ICU death. This highlighted the fact that ICU mortality rates were higher in patients with multiple organ failure on admission and in those who required organ support therapy such as mechanical ventilation or RRT.

In our cohort, we observed that the type of cancer had a significant impact on ICU mortality. Patients with lung cancer had a higher OR of 1.58 for ICU mortality, whereas patients with pancreas biliary cancer had a lower OR of 0.54. Qian et al. [13], reported that the main reason for ICU admission in lung cancer patients was pneumonia or respiratory failure. Similarly, most lung cancer patients in our study were admitted to the ICU for respiratory failure. The discovery of various molecular oncogenes and advances in targeted and immunotherapies have led to significantly increased life ex-

pectancy in patients with lung cancer because these treatments often allow patients (even those in advanced stages) to remain stable for a longer period of time [14]. However, this increase in life expectancy has also resulted in more cases of respiratory failure due to drug-induced pneumonitis or immune-related adverse events following targeted or immunotherapy [5]. Although ICU outcomes in patients who develop adverse events as a result of targeted therapy or immunotherapy may be better than those of conventional cytotoxic chemotherapy [15,16], patients manifesting respiratory failure had worse outcomes than patients with other causes of ICU admission in our cohort. In contrast, patients with pancreas biliary cancer were more likely to be admitted to the ICU for septic shock due to biliary infection or hemorrhagic shock due to bleeding [17]. Our study showed that approximately 2/3 of the patients with pancreas biliary cancer were admitted to the ICU due to shock, and patients with shock had a lower OR for ICU mortality than those with respiratory failure. Despite the poor oncological prognosis for pancreas-biliary cancer, interventions such as biliary drainage and embolization can often be useful for the rapid reversal of sepsis, potentially leading to a higher ICU survival rate. Therefore, our findings suggest that the ICU mortality in patients with solid malignancies is closely related to their cancer type and the cause of ICU admission.

Based on the high long-term mortality, the findings could be helpful to both intensivists and oncologists, providing important data to assist with the decision-making process for ICU admission of patients with solid malignancies. A previous Korean multi-center study that studied ICU patients with malignancies did not investigate the long-term outcomes [4]. In our cohort, the majority of the patients who required ICU admission did not survive beyond a year. Only a few studies have reported long-term outcomes between cancer and non-cancer patients after ICU admission. The Dutch National Cohort study reported that patients with cancer had a significantly worse one-year mortality rate than patients without cancer [8]. The authors suggested that the underlying cancer types or their treatments were important factors in recovery from critical illness. Puxty et al. [18] reported that the 6-month and 4-year mortality rates of surgical ICU patients with cancer were higher than those of the group without cancer. They suggested that long-term survival was related to the underlying cancer, although short-term outcomes were more related to critical illness. Our study presented one-year mortality rates from ICU admission and from ICU discharge. Even after surviving from the ICU, cancer patients in our cohort still had high one-year mortality. We found that cancer stages, patients' reception of further chemotherapy after ICU discharge, and patient and family's willingness to receive life-sustaining treatment were associated with the long-term mortality of cancer patients after critical illness. In patients with solid malignancies, the treatment provided in the ICU can disrupt the ongoing cancer treatments due to a decline in patients' functional status, active infections, or the development of new organ dysfunction, thereby delaying further cancer treatment until the patients' general condition and the infection or organ dysfunction improve [19]. Such delays can lead to poor outcomes in patients with advanced cancer. Given the significant difference in one-year mortality based on whether chemotherapy was restarted after ICU discharge in our patients with metastatic cancer, evaluating the possibility of restarting chemotherapy after critical illness could be helpful in making decisions on life-sustaining treatment. Our results suggested that ICU admission itself should be considered as critical point for prognosis in patients with solid malignancy. Further, when considering life-sustaining treatments for these patients, decision-making should be based on an understanding of the expected short- and long-term prognosis based on that ICU admission and an informed discussion between the patients, their family, and the treating physician.

This study has certain limitation. Given that this was a single-center study, the generalizability of the study results is limited. However, our study included a large number of patients with data collected from one of the largest referral hospitals in Korea over 7 years after the introduction of targeted therapy and immunotherapy. We believe that these results can be indicative of contemporary clinical courses for critically ill patients with solid malignancy.

In conclusion, this study showed that critically ill patients with solid malignancy had poor 1-year survival despite relatively low ICU mortality. The types of underlying cancer and organ support therapies received during the ICU stay were significantly associated with ICU mortality. These findings highlight the need for careful consideration of ICU admission in patients with solid malignancy, and decision-making should be based on an understanding of the short- and long-term prognosis of ICU admission after an informed discussion between the patients, their families, and the treating physician.

https://doi.org/10.3904/kjim.2024.054

KJIM

KEY MESSAGE

1. Critically ill patients with solid malignancy have low 1-year survival rates despite low ICU mortality.
2. Cancer types and organ support therapies have a significant impact on ICU mortality.
3. This study highlights the importance of careful ICU admission decisions for cancer patients, based on a thorough understanding of their prognosis and discussions between patients, families and clinicians.

REFERENCES

1. Lin L, Li Z, Yan L, Liu Y, Yang H, Li H. Global, regional, and national cancer incidence and death for 29 cancer groups in 2019 and trends analysis of the global cancer burden, 1990-2019. J Hematol Oncol 2021;14:197.
2. Martos-Benítez FD, Soler-Morejón CD, Lara-Ponce KX, et al. Critically ill patients with cancer: a clinical perspective. World J Clin Oncol 2020;11:809-835.
3. Zampieri FG, Romano TG, Salluh JIF, et al. Trends in clinical profiles, organ support use and outcomes of patients with cancer requiring unplanned ICU admission: a multicenter cohort study. Intensive Care Med 2021;47:170-179.
4. Na SJ, Ha TS, Koh Y, et al. Characteristics and clinical outcomes of critically ill cancer patients admitted to Korean intensive care units. Acute Crit Care 2018;33:121-129.
5. Vigneron C, Charpentier J, Valade S, et al. Patterns of ICU admissions and outcomes in patients with solid malignancies over the revolution of cancer treatment. Ann Intensive Care 2021;11:182.
6. Koutsoukou A. Admission of critically ill patients with cancer to the ICU: many uncertainties remain. ESMO Open 2017;2:e000105.
7. Schapira DV, Studnicki J, Bradham DD, Wolff P, Jarrett A. Intensive care, survival, and expense of treating critically ill cancer patients. JAMA 1993;269:783-786.
8. van der Zee EN, Termorshuizen F, Benoit DD, et al. One-year mortality of cancer patients with an unplanned ICU admission: a cohort analysis between 2008 and 2017 in the Netherlands. J Intensive Care Med 2022;37:1165-1173.
9. Darmon M, Bourmaud A, Georges Q, et al. Changes in critically ill cancer patients' short-term outcome over the last decades: results of systematic review with meta-analysis on individual data. Intensive Care Med 2019;45:977-987.
10. Ostermann M, Ferrando-Vivas P, Gore C, Power S, Harrison D. Characteristics and outcome of cancer patients admitted to the ICU in England, Wales, and Northern Ireland and national trends between 1997 and 2013. Crit Care Med 2017;45:1668-1676.
11. Wigmore T, Farquhar-Smith P. Outcomes for critically ill cancer patients in the ICU: current trends and prediction. Int Anesthesiol Clin 2016;54:e62-e75.
12. Nassar AP Jr, Dettino ALA, Amendola CP, Dos Santos RA, Forte DN, Caruso P. Oncologists' and intensivists' attitudes toward the care of critically ill patients with cancer. J Intensive Care Med 2019;34:811-817.
13. Qian J, Qin R, Hong L, et al. Characteristics and clinical outcomes of patients with lung cancer requiring ICU admission: a retrospective analysis based on the MIMIC-III database. Emerg Cancer Care 2023;2:1.
14. Chi SA, Yu H, Choi YL, et al. Trends in survival rates of non-small cell lung cancer with use of molecular testing and targeted therapy in Korea, 2010-2020. JAMA Netw Open 2023;6:e232002.
15. Toffart AC, Meert AP, Wallet F, et al. ICU admission for solid cancer patients treated with immune checkpoint inhibitors. Ann Intensive Care 2023;13:29.
16. Hong Y, Hong JY, Park J. Differences in ICU outcomes according to the type of anticancer drug in lung cancer patients. Front Med (Lausanne) 2022;9:824266.
17. Kemoun G, Weiss E, El Houari L, et al. Clinical features and outcomes of patients with pancreatic cancer requiring unplanned medical ICU admission: a retrospective multicenter study. Dig Liver Dis 2024;56:514-521.
18. Puxty K, McLoone P, Quasim T, Sloan B, Kinsella J, Morrison DS. Characteristics and outcomes of surgical patients with solid cancers admitted to the intensive care unit. JAMA Surg 2018;153:834-840.
19. Borcoman E, Dupont A, Mariotte E, et al. One-year survival in patients with solid tumours discharged alive from the intensive care unit after unplanned admission: a retrospective study. J Crit Care 2020;57:36-41.

Received : February 16, 2024
Revised : June 6, 2024
Accepted : July 12, 2024

Correspondence to
Jee Hwan Ahn, M.D., Ph.D.
Department of Pulmonary and Critical Care Medicine, Asan Medical Center, University of Ulsan College of Medicine, 88 Olympic-ro 43-gil, Songpa-gu, Seoul 05505, Korea
Tel: +82-2-3010-1718, Fax: +82-2-3013-6968
E-mail: ggaamang24@amc.seoul.kr
https://orcid.org/0000-0001-6653-998X

CRedit authorship contributions
Su Yeon Lee: methodology, resources, investigation, data curation, formal analysis, validation, software, writing - original draft, writing - review & editing, visualization; Jin Won Huh: resources, investigation, validation, writing - review & editing; Sang-Bum Hong: resources, investigation, validation, writing - review & editing; Chae-Man Lim: resources, investigation, validation, writing - review & editing; Jee Hwan Ahn: conceptualization, methodology, resources, investigation, data curation, formal analysis, validation, software, writing - original draft, writing - review & editing, visualization, supervision, project administration

Conflicts of interest
The authors disclose no conflicts.

Funding
None

https://doi.org/10.3904/kjim.2024.054

Supplementary Table 1. ICU admission causes according to cancer types

Variable	Lung (n = 327)	Breast (n = 54)	Urogenital (n = 76)	Pancreas biliary (n = 206)	Others (n = 292)	*p* value
Admission causes						< 0.001
Respiratory failure	222 (67.9)	35 (64.8)	26 (34.2)	34 (16.5)	124 (42.5)	
Shock	38 (11.6)	9 (16.7)	28 (36.8)	125 (60.7)	80 (27.4)	
Cardiac arrest	18 (5.5)	2 (3.7)	6 (7.9)	8 (3.9)	17 (5.8)	
Altered mental status	13 (4.0)	3 (5.6)	6 (7.9)	8 (3.9)	17 (5.8)	
Metabolic acidosis	5 (1.5)	1 (1.9)	3 (4.0)	7 (3.4)	10 (3.4)	
Post-operative/procedure	20 (6.1)	1 (1.9)	2 (2.6)	7 (3.4)	22 (7.5)	
Others	11 (3.4)	3 (5.6)	5 (6.6)	17 (8.3)	22 (7.5)	

Values are presented as number (%).
ICU, intensive care unit.

Supplementary Table 2. Missing variables and their number for 955 patients

Missing variable	Number
BMI	27
Hemoglobin	11
WBC	11
Platelet	11
BUN	11
Creatinine	7
Total bilirubin	17
Prothrombin time	46
Albumin	15
CRP	36
Lactic acid	13

BMI, body mass index; WBC, white blood cell; BUN, blood urea nitrogen; CRP, C-reactive protein.

https://doi.org/10.3904/kjim.2024.054

Supplementary Table 3. Causes of ICU admission and unadjusted ICU mortality

Causes of ICU admission	OR	95% CI	*p* value
Respiratory failure (reference)	1		
Shock	0.35	0.23–0.52	< 0.001
Cardiac arrest	1.77	0.95–3.28	0.070
Altered mental status	0.59	0.26–1.22	0.200
Metabolic acidosis	1.08	0.43–2.50	0.900
Post-operative/procedure	0.10	0.02–0.32	0.001
Others	0.28	0.11–0.63	0.004

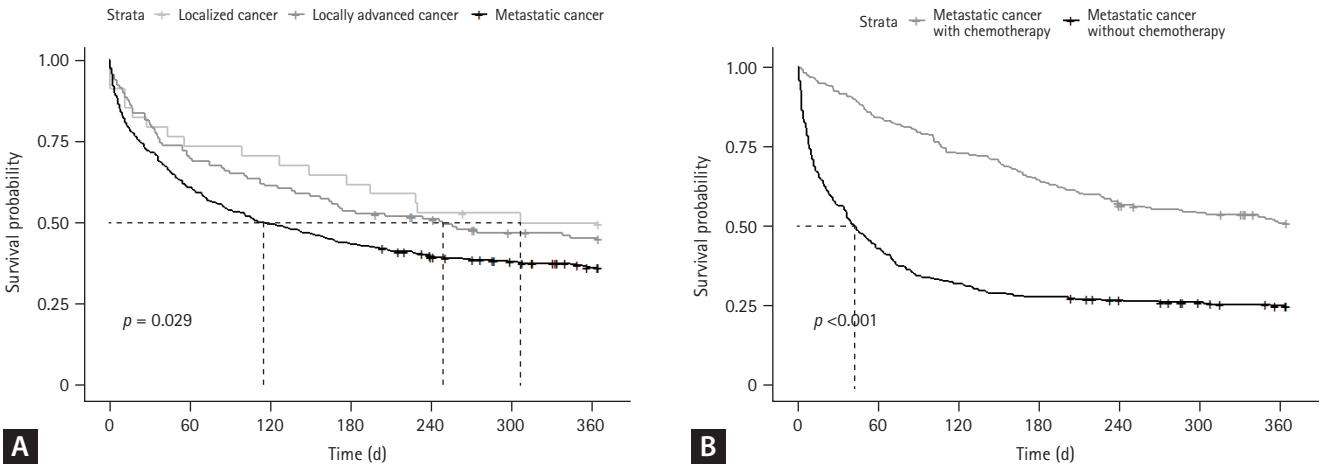
ICU, intensive care unit; OR, odds ratio, CI, confidence interval.

Supplementary Table 4. Causes of in-hospital death without ICU re-admission among ICU survivors (n = 178/731)

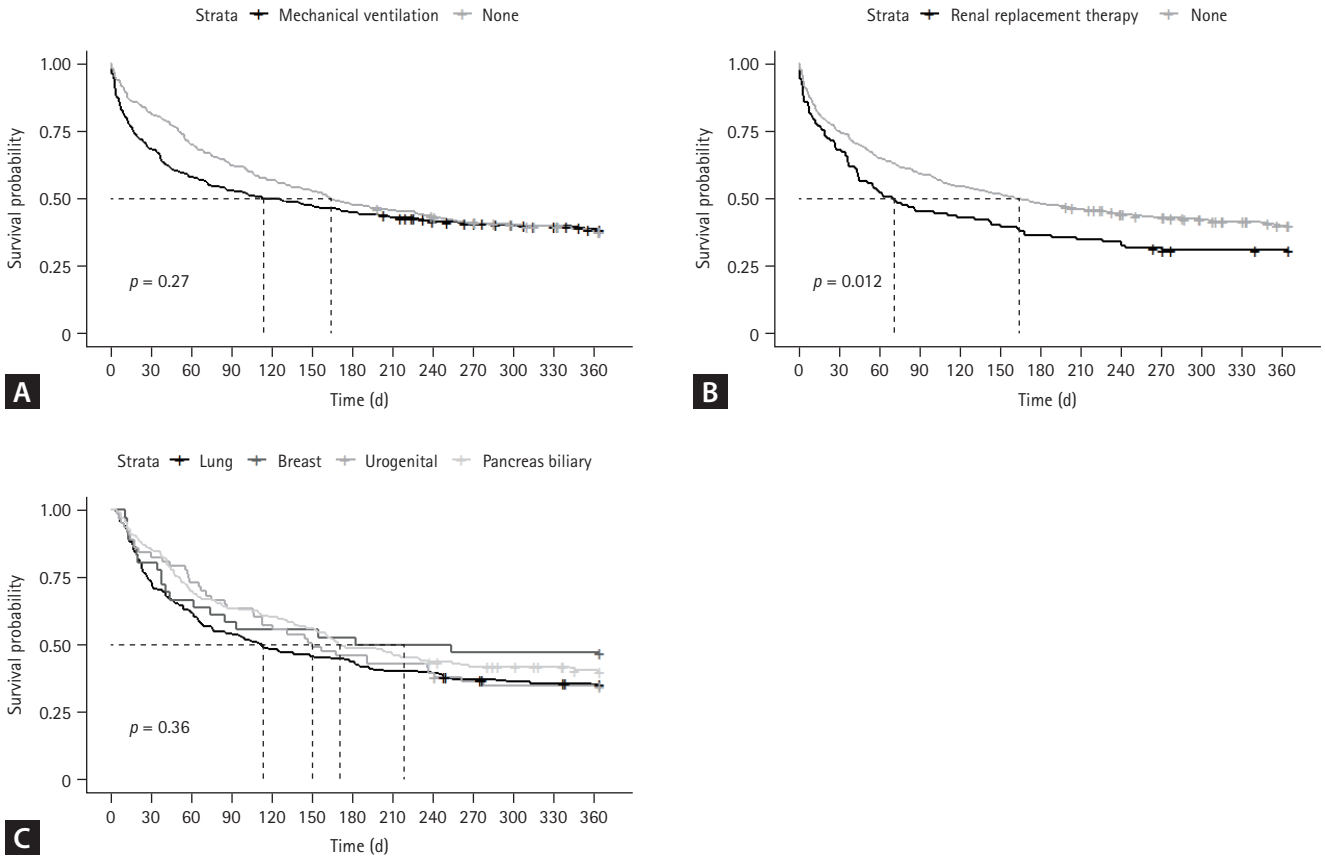
Causes of hospital death	Value (n = 178)
ICU readmitted and died in ICU	31 (17.4)
No ICU readmitted	147 (82.6)
Limitation of treatment by patient or family	141 (79.2)
Hopeless state at ICU discharge	1 (0.6)
Cardiac arrest	1 (0.6)
Death while waiting for admission to ICU	4 (2.2)

Values are presented as number (%).
ICU, intensive care unit.

https://doi.org/10.3904/kjim.2024.054



Supplementary Figure 1. One-year survival curves after ICU discharge in ICU survived cancer patient. (A) Based on cancer stages. The median survival was 307 days, 249 days, and 113 days, respectively. (B) Based on whether chemotherapy was done after ICU discharge. The median survival was 383 days and 42 days, respectively. ICU, intensive care unit.



Supplementary Figure 2. One-year survival curve after ICU discharge using Kaplan–Meier and Log-rank test. (A) Whether receiving mechanical ventilation during ICU. The median survival was 113 days and 164 days, respectively. (B) Whether receiving renal replacement therapy during ICU. The median survival was 70 days and 164 days, respectively. (C) According to cancer types. The median survival was 106 days, 175 days, 143 days, and 167 days, respectively. ICU, intensive care unit.

https://doi.org/10.3904/kjim.2024.054