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Retrospective Analysis of the Treatment Management and Clinical Outcomes of Critically Ill Tuberculosis Patients in the Intensive Care Unit

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ABSTRACT

Objective: Tuberculosis (TB) has emerged as a significant cause of morbidity and mortality within intensive care units (ICUs). This study evaluates the clinical characteristics and treatment processes of TB patients in ICUs to inform management strategies.

Materials and Methods: This multicenter retrospective study assessed newly diagnosed TB cases admitted to ICUs between January 2019 and January 2024. The primary outcome was mortality rates, while secondary outcomes included clinical characteristics affecting mortality. Medical records from six hospitals were reviewed for active TB patients with confirmed diagnoses.

Results: Among 67 ICU patients studied, 34 (51%) died. Significant associations with increased mortality were found for lower Glasgow Coma Scale scores (GCS) (p=0.003), higher Sequential Organ Failure Assessment (SOFA) scores (p=0.020), and elevated Acute Physiology and Chronic Health Evaluation II (APACHE II) scores (p=0.004). Mortality rates were notably higher in patients with multiple comorbidities and nutritional deficiencies. Cox regression analysis identified the Charlson Comorbidity Index (hazard ratio [HR]=1.35, p=0.031) and modified Nutrition Risk in Critically Ill (mNUTRIC) score (HR=1.39, p=0.0483) as significant mortality predictors. Kaplan-Meier analysis indicated that patients with high mNUTRIC scores had significantly lower survival probabilities (p=0.004).

Conclusion: Approximately half of the ICU patients with TB died during hospitalization. This study highlights nutritional deficiencies as a key mortality predictor, aiding in the development of improved treatment strategies for TB patients in critical care settings.

Keywords: Critical illness, intensive care unit, mortality, tuberculosis.

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INTRODUCTION

Tuberculosis (TB) continues to be a significant global health issue. According to the World Health Organization (WHO), approximately one-quarter of the global population is infected with *Mycobacterium tuberculosis* (*M. tuberculosis*), and TB is still one of the leading causes of death worldwide.[1] Although the incidence of TB in Türkiye shows a declining trend, it remains a major health concern. During the Coronavirus Disease 2019 (COVID-19) pandemic, fluctuations in TB case numbers were observed, and according to 2021 data, a total of 11,954 TB cases were recorded in Türkiye.[2]

The mortality rates among TB patients admitted to the intensive care unit (ICU) remain high. Reasons for ICU admission in these patients include severe complications such as acute respiratory failure, mycobacterial septic shock, and multiple organ dysfunction syndrome (MODS).[3] Tuberculous meningitis is also a common reason for ICU admission among these patients.[4]

Managing TB patients in the ICU is complex and challenging. Acute respiratory failure is one of the most common reasons for ICU admission among TB patients, and the need for mechanical ventilation is associated with high mortality rates in these patients.[5] The mortality rate for TB patients requiring mechanical ventilation exceeds 60%.[6] Additionally, the need for vasopressors is associated with high mortality and significantly reduces the chances of survival for these patients.[7]

Optimizing treatment regimens is critical in the management of TB in the ICU. The use of optimal drug regimens plays a crucial role in improving survival rates among these patients.[8]

Tuberculosis patients co-infected with Human Immunodeficiency Virus (HIV) are more vulnerable to TB infection due to their weakened immune systems, and ICU admission and mortality rates are higher among these patients. The mortality rate of HIV-positive TB patients in the ICU is significantly higher compared to HIV-negative patients.[9] This underscores the importance of specialized approaches and treatment protocols in managing TB patients with HIV infection.[10]

In conclusion, managing TB in the ICU presents a major challenge due to high mortality rates and complex treatment processes. This study aims to evaluate the clinical characteristics and treatment processes of TB patients admitted to the ICU, contributing to the development of management strategies for these patients.

KEY MESSAGES

- High Mortality Rates: Consistent with other studies, highlighting the severity of tuberculosis (TB) in intensive care unit (ICU) settings.
- Comorbidities: High Charlson Comorbidity Index (CCI) is associated with worse outcomes.
- Mortality Factors: High Acute Physiology and Chronic Health Evaluation II (APACHE II) and Sequential Organ Failure Assessment (SOFA) scores, nutritional deficiencies, mechanical ventilation, and vasopressor support are key predictors of mortality.

MATERIALS AND METHODS

Study Design and Participants

This multicenter retrospective study aims to determine mortality rates and evaluate the clinical characteristics of TB cases admitted to the ICU. Clinical files of all active TB patients in the medical ICUs of six hospitals from January 1, 2019 to January 1, 2024, were retrospectively reviewed. All patients with a confirmed diagnosis of TB through laboratory samples and ICU admission were included in the study.

Inclusion Criteria and Data Collection

Inclusion criteria:

- Individuals with a confirmed diagnosis of active TB receiving care in the ICU.
- Individuals exhibiting both clinical symptoms and radiological evidence of TB, supported by positive *M. tuberculosis* cultures or acid-fast bacillus (AFB) smears from biological fluids such as sputum, bronchial aspirates, bronchoalveolar lavage, cerebrospinal, pleural, or peritoneal fluids, and receiving care in an ICU.
- Patients with biopsy-confirmed caseating granulomas consistent with TB.

All data were obtained from hospital records. The collected data included:

- Demographic Data: Age, gender.
- Clinical Data: Basic clinical data such as the need for mechanical ventilation during the patients' stay, treatments administered, and accompanying comorbidities were recorded in the patient files. In this study, several scoring systems were used to assess the severity of illness and predict outcomes in critically ill TB patients, including the Sequential Organ Failure Assessment (SOFA) score, Acute

Physiology and Chronic Health Evaluation II (APACHE II) score, Charlson Comorbidity Index (CCI), Glasgow Coma Scale (GCS), and the Modified Nutrition Risk in Critically Ill (mNUTRIC) score.

- Laboratory Data: Biochemical tests, as well as microbiological and mycobacteriological results found in the patient files, were documented.

Outcomes

The primary outcome is the mortality rate of newly diagnosed TB cases admitted to ICUs, and the secondary outcome is the determination of clinical characteristics influencing mortality.

Ethics Committee Approval: Erciyes University Clinical Research Ethics Committee granted approval for this study (date: 14.02.2024, number: 2024/106).

Statistical Analysis

The statistical analyses of the data were conducted using R software (https://cran.r-project.org/, version 4.3.3) and TURCOSA software (www.turcosa.com.tr, Access Date: June 15, 2024). The normality of numerical data was assessed using both graphical methods (Q-Q plot, histogram, etc.) and hypothesis tests (Shapiro-Wilk normality test). We summarized numerical data following a normal distribution using averages and measures of how much the data vary, whereas data that did not conform to a normal distribution were summarized using medians and interquartile ranges. Categorical data were summarized using frequencies and percentages. The mortality of TB patients was evaluated using Kaplan-Meier analysis and Cox regression models. Independent risk factors for mortality were explored using univariate Cox regression models. Variables with a p-value below 0.10 were included in the multiple Cox regression model, and the final model was fitted. Hazard ratios and 95% confidence intervals were reported. The level of statistical significance was set at $p<0.05$ for all analyses.

RESULTS

In this multicenter retrospective study, 67 patients admitted to six different ICUs between January 2019 and January 2024 were included. Among these patients, 34 (51%) died. The mean age of patients was 53 years (range: 18–100), with a higher proportion of male patients (65.7%). Age and gender differences between survivors and non-survivors were not statistically significant (p=0.317).

Thirty-six patients (53.7%) were diagnosed with TB before their ICU admission, while 31 patients (46.3%) were diagnosed during their ICU stay. For patients diagnosed after admission to the ICU, the average time to diagnosis was eight days.

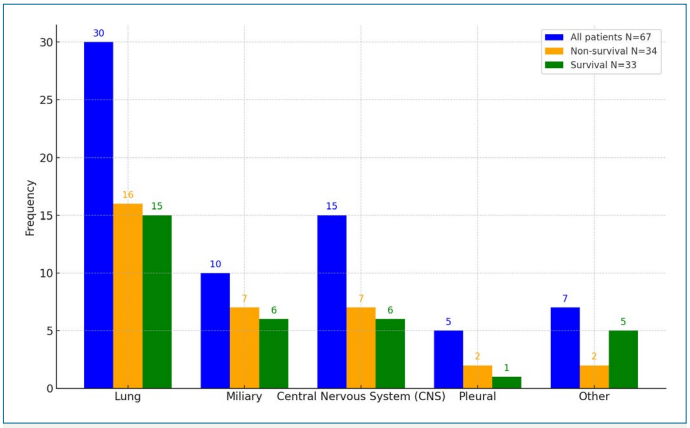

Figure 1. Distribution of tuberculosis forms among deceased and surviving patients. This figure illustrates the distribution of different forms of tuberculosis among patients who survived and those who did not survive their intensive care unit (ICU) stay. Pulmonary tuberculosis was the most common form observed in both groups, followed by miliary tuberculosis and central nervous system (CNS) tuberculosis. The analysis shows that the type of tuberculosis form did not significantly impact mortality.

Reasons for ICU admission were as follows: 28 patients (41.8%) were admitted due to respiratory failure, 21 patients (31.3%) due to neurological deterioration, seven patients (10.4%) due to sepsis, and 11 patients (16.4%) due to other reasons (Table 1).

Among the 67 patients, the most common form of oxygen support was mechanical ventilation (MV), which was used in 26 patients (38.8%). Nasal or mask oxygen was used in 21 patients (31.3%), room air in 12 patients (17.9%), high-flow nasal oxygen (HFNO) in four patients (6%), and non-invasive mechanical ventilation (NIMV) in four patients (6%) (Table 1).

When evaluating treatments initiated for the patients, it was found that quadruple anti-tuberculosis therapy was started in 15 patients (22.3%) without a definitive diagnosis; however, tuberculosis was later confirmed in these patients through laboratory tests. In three patients (4.4%), treatment could not be initiated as the diagnosis was made postmortem. In 49 patients (73.1%), treatment was initiated following a definitive diagnosis (p=0.488).

The most common reason for ICU admission was respiratory failure, accounting for 28 patients (41.8%). This was followed by neurological deterioration in 21 patients (31.3%), sepsis in seven patients (10.4%), and other reasons in 11 patients (16.4%). When comparing the reasons for ICU admission between deceased and surviving patients, respiratory

Table 1. Demographic and clinical characteristics of the participants upon admission in the intensive care unit (ICU)

Variables	All patients (n=67)	Survival (n=33)	Non-survival (n=34)	p
Age, years (median) (min–max)	55 (18–100)	52 (23–100)	55 (18–91)	0.317
Gender, n (%)				
Male	23 (34)	12 (35)	11 (33)	
Female	44 (66)	22 (65)	22 (67)	
Reason for ICU admission, n (%)				**0.042**
Respiratory failure	28 (42)	19 (56)	9 (27)	
Neurological deterioration	21 (31)	9 (27)	12 (36)	
Sepsis	7 (10)	5 (15)	2 (6)	
Other	11 (16)	1 (3)	10 (30)	
APACHE II score, (median) (min–max)	19 (1–42)	16 (2–28)	23.5 (1–42)	**0.004**
Modified NUTRIC score, (median) (min–max)	4 (0–8)	2 (0–5)	4.5 (0–8)	**0.004**
SOFA score, (median) (min–max)	6 (0–19)	4 (0–12)	8 (3–19)	**0.020**
Charlson Comorbidity Index (min–max)	3.6 (0–3.6)	2 (0–11)	4 (0–13)	**0.035**
Oxygen support, n (%)				**0.022**
Invasive mechanical ventilation	26 (38.8)	4 (12.1)	22 (64.7)	
Non-invasive mechanical ventilation	4 (6)	2 (6.1)	2 (5.9)	
HFNO	4 (6)	2 (6.1)	2 (5.9)	
Nasal oxygen	21 (31.3)	14 (42.4)	7 (20.6)	
Room air	12 (17.9)	11 (33.3)	1 (2.9)	
Acute kidney injury, n (%)	31 (46.3)	22 (64)	9 (27)	0.087
Renal replacement therapy, n (%)	14 (20.9)	2 (6.1)	12 (35.3)	0.073
CRRT	5 (7.5)	0 (0)	5 (14.7)	
IHD	9 (13.4)	2 (6.1)	7 (20.6)	
Vasopressor drugs, n (%)	38 (56.7)	6 (18.2)	32 (94.1)	**0.001**

ICU: Intensive care unit; APACHE II: Acute physiology and chronic health evaluation II; NUTRIC: Nutrition risk in critically ill; SOFA: Sequential organ failure assessment; HFNO: High-flow nasal oxygen; CRRT: Continuous renal replacement therapy; IHD: Intermittent hemodialysis.

Table 2. Multiple Cox regression model for prognostic scores

Variable	Coefficient (coef)	Hazard ratio (exp (coef))	Standard error (SE)	z	p	95% Confidence interval (exp (coef))
GCS	-0.017	0.982	0.049	-0.350	0.726	0.891–1.083
APACHE II	0.028	1.029	0.041	0.697	0.486	0.949–1.117
mNUTRIC	0.330	1.392	0.162	2.039	0.048	1.046–1.849
SOFA	0.065	1.067	0.072	0.896	0.370	0.926–1.231

GCS: Glasgow Coma Scale; APACHE: Acute physiology and chronic health evaluation; mNUTRIC: Modified nutrition risk in critically ill; SOFA: Sequential organ failure assessment.

failure remained the most common reason among deceased patients, with 19 patients (55.9%) admitted for this cause. Neurological deterioration was the reason for ICU admission in nine deceased patients (26.5%), sepsis in five deceased patients (14.7%), and other reasons in one deceased patient (2.9%).

Table 3. Laboratory values for all patients, survivors, and non-survivors

Laboratory value	Median (min–max) all patients (n=67)	Median (min–max) survivors (n=33)	Median (min–max) non-survivors (n=34)	p
WBC (µL)	8500 (1700–31020)	8200 (1700–31020)	17800 (8180–30050)	**0.023**
NET (µL)	6800 (1200–25000)	6700 (1200–25000)	6900 (3000–29000)	0.055
Lymphocyte (µL)	630 (200–2000)	610 (200–2000)	650 (250–2100)	0.153
PLT (µL)	190000 (50000–500000)	185000 (50000–500000)	195000 (60000–520000)	0.089
HGB (g/dL)	12.5 (5.0–18.0)	12.3 (5.0–18.0)	12.7 (6.0–20.0)	0.067
Glucose (mg/dL)	80 (50–150)	78 (50–150)	82 (55–160)	0.112
BUN (mg/dL)	30 (10–90)	28 (10–90)	32 (15–100)	**0.031**
Creatinine (mg/dL)	1.8 (0.5–6.0)	1.7 (0.5–6.0)	1.9 (0.7–6.5)	0.054
Sodium (mEq/L)	135 (120–150)	134 (120–150)	136 (125–155)	0.073
Potassium (mEq/L)	4.0 (3.0–6.0)	3.9 (3.0–6.0)	4.1 (3.2–6.5)	0.085
Chloride (mEq/L)	97 (90–110)	96 (90–110)	98 (91–112)	0.099
AST (U/L)	30 (10–100)	28 (10–100)	32 (15–110)	**0.025**
ALT (U/L)	20 (5–50)	19 (5–50)	21 (7–55)	0.042
Total bilirubin (mg/dL)	0.7 (0.2–2.0)	0.6 (0.2–2.0)	0.8 (0.3–2.2)	0.110
Albumin (g/dL)	4.0 (2.5–5.5)	3.9 (2.5–5.5)	4.1 (2.8–5.7)	0.078
LDH (U/L)	800 (200–2000)	770 (200–2000)	830 (300–2100)	0.039
CRP (mg/dL)	250 (50–600)	240 (50–600)	260 (60–620)	0.048

WBC: White blood cell; NET: Neutrophil; PLT: Platelet; HGB: Hemoglobin; BUN: Blood urea nitrogen; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; LDH: Lactate dehydrogenase; CRP: C-Reactive protein.

Among the outcomes, 47.1% of deceased patients had pulmonary TB, compared to 45.5% of survivors who also had this form of TB. Miliary TB and central nervous system (CNS) TB were each found in 20.6% of deceased patients and 18.2% of surviving patients. Pleural TB was present in 5.9% of deceased patients and 3% of surviving patients. Other forms were observed in 5.9% of deceased patients and 15.2% of surviving patients (Fig. 1).

Statistical analysis showed that the type of TB form did not significantly impact mortality (p=0.488). This suggests that, while different forms of TB were present in both deceased and surviving patients, the type of TB alone was not a determining factor for the outcome in this cohort.

No resistance to anti-tuberculosis drugs was observed in any of the patients diagnosed with TB. Treatment was administered exclusively with the standard quadruple anti-tuberculosis therapy. Adverse effects to anti-TB drugs developed in 10 patients (17.7%). Among these, treatment modifications were necessary for only one patient (1.5%) due to hepatotoxicity. The adverse effects observed included hepatotoxicity in three patients (4.5%), acute kidney injury (AKI) in five patients, and hypersensitivity reactions in two patients (3%). In addition to the existing anti-TB treatment, steroids were added to the regimen for 38 patients (56.7%).

Twelve patients (17.9%) had received immunosuppressive therapy. Among those who died, eight patients (23.5%) were in this group, compared to four patients (12.4%) among the survivors. There was no statistically significant difference between the two groups (p=0.637).

Radiological findings in the lungs at the time of admission were as follows: cavitary lung appearance in 16 patients (23.9%), miliary lung appearance in 15 patients (22.3%), acute respiratory distress syndrome (ARDS) in five patients (7.5%), and nonspecific appearance in 31 patients (46.3%).

The diagnosis of TB was made from sputum samples in 42 patients (62.7%), cerebrospinal fluid (CSF) samples in nine patients (13.4%), tissue samples in seven patients (10.4%), and blood samples in one patient (1.5%). Diagnostic methods included polymerase chain reaction (PCR) in 12 patients (17.9%), acid-fast bacilli staining in 19 patients (28.4%), culture

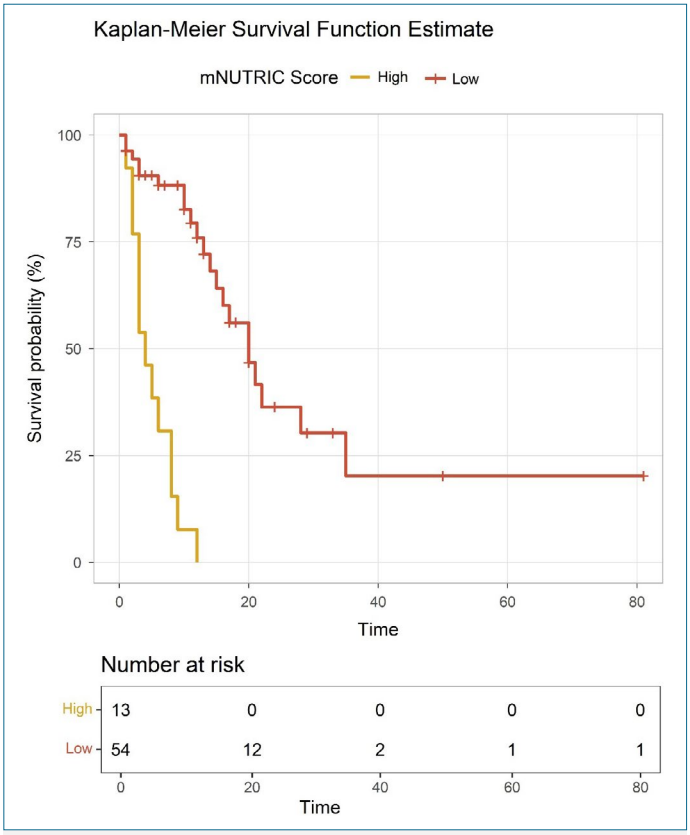

Figure 2. Kaplan-Meier survival curve based on Modified Nutrition Risk in the Critically Ill (mNUTRIC) scores. The Kaplan-Meier survival curve shows the survival probabilities over time for patients categorized by their mNUTRIC scores. Patients with high mNUTRIC scores had significantly lower survival probabilities compared to those with low mNUTRIC scores. This figure supports the finding that the mNUTRIC score is a strong predictor of mortality in intensive care unit (ICU) patients with tuberculosis.

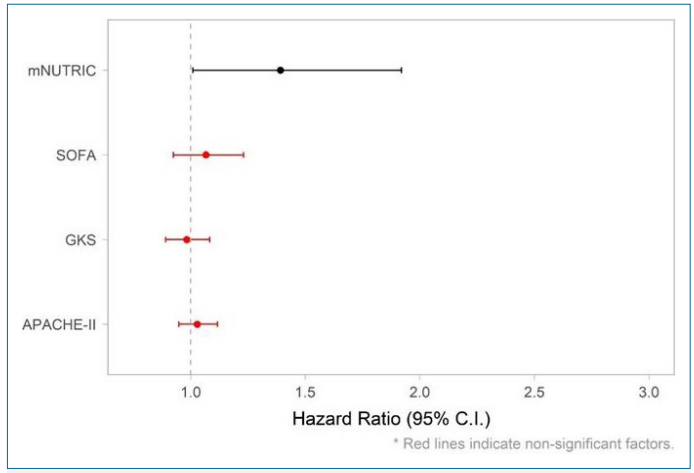

Figure 3. Hazard ratios for various prognostic scores. This figure presents the hazard ratios for different prognostic scores, including the Glasgow Coma Scale (GCS), Acute Physiology and Chronic Health Evaluation II (APACHE II), Modified Nutrition Risk in the Critically Ill (mNUTRIC), and Sequential Organ Failure Assessment (SOFA) scores. The mNUTRIC score (coefficient=0.33097, p=0.0483) was the only significant predictor in the model, indicating that each unit increase in the mNUTRIC score increases the hazard of death by approximately 39% (hazard ratio [HR]=1.3923). Other variables, such as GCS, APACHE II, and SOFA scores, were not statistically significant predictors of mortality in this model.

in 20 patients (29.9%), clinical diagnosis in 12 patients (17.9%), and other methods in four patients (6.0%).

Based on epidemiological and radiographic findings, the median time from hospital admission to the initiation of treatment was three days (range: 1–8).

Comorbid conditions were identified in 54 patients (81.6%). Only one patient (1.5%) was co-infected with HIV. The median Charlson Comorbidity Index was 2 (range: 0–13). The median CCI was 4 for patients who died and 2 for those who survived. It was demonstrated that ICU admission due to TB contributed to mortality in patients with multiple comorbidities (p=0.031).

mNUTRIC score for the entire population was 4 (range: 0–11). The median mNUTRIC score was 4.5 for those who died and 2 for those who survived. It was found that patients with nutritional deficiencies at the time of ICU admission had higher mortality rates (p=0.004).

The Kaplan-Meier survival curve demonstrates the survival probabilities over time for patients categorized by their mNUTRIC scores. Patients with high mNUTRIC scores had significantly lower survival probabilities compared to those with low mNUTRIC scores, further supporting the finding that the mNUTRIC score is a strong predictor of mortality (Fig. 2).

The overall median Glasgow Coma Scale score for all patients was 13 (range: 3–15). When comparing the outcomes, the median GCS score for patients who died was significantly lower at 8 (range: 3–15) compared to 15 (range: 6–15) for those who survived. Statistical analyses demonstrated that a lower GCS score at the time of ICU admission was significantly associated with higher mortality (p=0.003). This indicates that patients with lower GCS scores, which reflect a more severe level of impaired consciousness, had a higher risk of mortality during their ICU stay.

The median SOFA score for all patients was 6 (range: 0–24). The median SOFA score was 8 (range: 4–19) for those who died and 4 (range: 0–15) for those who survived. It was demonstrated that a high SOFA score at the time of ICU admission contributed to mortality (p=0.020).

The median APACHE II score was 19 (range: 1–42). The median score was 23 for patients who died and 16 for those who survived. Statistically, a higher APACHE II score significantly contributed to mortality (p=0.004).

The mNUTRIC score stands out as a valuable tool in predicting outcomes for ICU patients. Both Cox regression analysis and Kaplan-Meier survival estimates (Fig. 2, Table 2) consistently demonstrated that higher mNUTRIC scores are associated with increased mortality.

In the model, the mNUTRIC score (coefficient=0.33097, p=0.0483) was the only significant predictor, indicating that each unit increase in the mNUTRIC score raises the hazard of death by approximately 39% (hazard ratio [HR]=1.3923). Other variables, such as GCS, APACHE-II, and SOFA scores, were not statistically significant predictors of mortality in this model (Fig. 3).

When comparing the outcomes, it was observed that 64.7% of deceased patients required mechanical ventilation, while only 12.1% of surviving patients needed the same level of support. Conversely, room air was sufficient for 33.3% of surviving patients, compared to only 2.9% of deceased patients. Nasal or mask oxygen support was also more common among survivors (42.4%) than deceased patients (20.6%).

Statistical analysis showed that the need for oxygen support at ICU admission was significantly associated with mortality (p=0.022).

During their ICU stay, 38 patients (56.7%) developed a need for vasopressors (VP). Among those who died, 32 patients (94.1%) required VP, compared to six patients (18.2%) among the survivors. The need for VP was significantly higher in patients who died (p=0.001).

Nosocomial infections developed in 38 patients (56.7%) during their ICU stay. Among the patients who died, 25 (73.5%) developed an infection, compared to 13 (39.4%) among the survivors (p=0.105).

During their ICU stay, 31 patients (46.3%) developed acute kidney injury. Among these patients, 14 (20.9%) required renal replacement therapy (RRT). Of those, five received continuous renal replacement therapy (CRRT) and nine received intermittent hemodialysis (HD). In the group of patients who died, 12 (35.3%) required RRT, with five receiving CRRT and nine receiving intermittent HD. Only two survivors (3%) required RRT. The development of kidney failure did not have a significant impact on mortality (p=0.120).

According to the findings presented in Table 3, non-survivors had significantly higher levels of white blood cell (WBC) count (p=0.023), blood urea nitrogen (BUN) (p=0.031), aspartate aminotransferase (AST) (p=0.025), alanine aminotransferase (ALT) (p=0.042), lactate dehydrogenase (LDH) (p=0.039), and C-reactive protein (CRP) (p=0.048) compared to survivors.

DISCUSSION

This study comprehensively examined the factors affecting mortality in TB patients treated in the ICU. Our findings indicate that TB is a severe disease requiring ICU admission and is associated with high mortality rates. The results of our study are consistent with similar studies in the literature and underscore that TB is a significant cause of morbidity and mortality in patients requiring ICU care.

In our study, 51% of TB patients admitted to the ICU died. This rate is similar to other studies. Hagan and Nathani[3] reported that the mortality rates in patients admitted to the ICU due to TB range from 17.5% to 81%. A meta-analysis by Muthu et al.[4] reported a mortality rate of 65% in patients requiring mechanical ventilation due to TB. Frame et al.[5] reported a 67% mortality rate in 43 active TB patients. In our univariate analysis, the need for MV in our patient group was also associated with increased mortality, though this was not significant in the multivariate analysis.

Treatment delay is another significant factor adversely affecting mortality in TB patients. Delayed treatment initiation in ICU patients monitored for TB has been identified as a factor negatively impacting mortality.[9]

In our study, the median mNUTRIC score for the entire cohort was strongly linked to mortality (p=0.004). Survival analysis using the Kaplan-Meier method reveals that patients with elevated mNUTRIC scores are more likely to experience worse survival outcomes. This finding aligns with previous research indicating that the mNUTRIC score effectively predicts 28-day mortality in ICU patients, with higher scores associated with poorer outcomes.[11] Integrating the mNUTRIC score into clinical practice for ICU TB patients can provide valuable prognostic information and guide therapeutic interventions. By identifying patients at higher nutritional risk, healthcare providers can tailor nutritional support and other critical care strategies to improve patient outcomes. This underscores the role of the mNUTRIC score as a fundamental tool in the comprehensive management of critically ill TB patients.

We found that patients with a high Charlson Comorbidity Index had higher mortality rates, highlighting the importance

of comorbidities as a prognostic factor in TB patients. Similar to our findings, other studies have demonstrated that patients with multiple health conditions generally experience poorer outcomes.[6] While there was no significant difference in mortality rates between patients who received immunosuppressive therapy and those who did not, it is evident that these patients require closer monitoring in the ICU.[12]

Managing TB patients co-infected with HIV requires specialized treatment approaches and protocols. Higher mortality rates in these patients have also been reported in the literature. Our study found that TB patients co-infected with HIV had a worse prognosis compared to those without HIV.[13] Only one patient in our study had HIV, which is fewer compared to other studies, and this patient died.

Our study also found that higher SOFA scores were associated with increased mortality. High SOFA scores indicate the severity of organ failure and the intensity of the systemic inflammatory response. This finding highlights the importance of the SOFA score as a significant prognostic indicator in TB patients. Similar to our findings, a study by Ryu et al.[7] also found that high SOFA scores were associated with increased mortality.

High APACHE II and SOFA scores were associated with mortality in TB patients treated in the ICU. These scoring systems are widely used to assess the overall condition and degree of organ failure in patients and are essential tools for determining the prognosis in TB patients. Research conducted by Ryu et al.[7] revealed that an APACHE II score exceeding 20, coupled with the occurrence of sepsis, were strongly indicative of an increased risk of death. Our study also found that patients with high scores had higher mortality rates. High APACHE II and SOFA scores, early ICU admission, the need for mechanical ventilation, and vasopressor support were significantly associated with mortality.[14]

Early initiation of treatment is essential for improving survival rates, especially in severe conditions such as mechanical ventilation and septic shock.[10]

Sepsis, nosocomial pneumonia, and the need for mechanical ventilation are associated with mortality in active TB patients. In our study, 43.8% of patients who died in the ICU received mechanical ventilation, and 62.5% of these patients died. Delayed antibiotic treatment also significantly impacts mortality. A study by Zahar et al.[9] found that delayed treatment increased mortality in ICU patients with severe active pulmonary TB.

The need for invasive mechanical ventilation was also associated with mortality. "Patients requiring invasive mechanical ventilation have a 7.58 times higher risk of mortality".[15] Severe sepsis or septic shock, the need for mechanical ventilation, vasopressor support, and acute kidney injury at ICU admission were identified as factors increasing mortality.[16]

Our laboratory results showed that patients who passed away had significantly elevated levels of white blood cells, neutrophil extracellular traps (NET), and blood urea nitrogen compared to those who recovered. The median WBC value for all patients was 8,500 (range: 1,700–31,020). in surviving patients, while it was 17,800 (range: 8,180–30,050) in patients who died, with the difference being statistically significant (p=0.023). Similarly, NET and BUN values were also significantly higher in patients who died. These findings underscore the prognostic importance of inflammation and renal function in TB patients. Elevated BUN levels, in particular, play a critical role in the prognosis of TB patients as an indicator of AKI. Additionally, elevated CRP and LDH levels were also associated with mortality.[14,17]

Our study has some limitations. Firstly, as a retrospective design, there is a risk of data omissions and information bias. Although this study was conducted in multiple centers, the retrospective nature of the data may still limit the generalizability of the results.

CONCLUSION

Approximately half of the patients died while in the ICU. This study makes a significant contribution to identifying factors affecting mortality in TB patients treated in the ICU. Inadequate nutrition has been shown to significantly contribute to mortality among ICU patients. Factors such as the presence of comorbidities, high APACHE II and SOFA scores, and the need for mechanical ventilation and vasopressor support are strongly associated with mortality. These findings can guide clinical decision-making in the management of TB patients in the ICU and help develop targeted interventions to improve prognosis.

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