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Prognostic Value of Computed Tomography-Measured Visceral Adipose Tissue in Patients with Pulmonary Infection Caused by Carbapenem-Resistant *Klebsiella pneumoniae*

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Objective: This study aimed to investigate the correlation between computed tomography (CT) derived body composition and 30-day mortality in patients with pulmonary infections caused by carbapenem-resistant *Klebsiella pneumoniae* (*K. pneumoniae*).

Methods: A total of 89 eligible participants from a tertiary teaching hospital, enrolled between January 1, 2016, and December 31, 2020, were included in the study. We analyzed the relationship between visceral adipose tissue (VAT), subcutaneous adipose tissue (SAT), total adipose tissue (TAT), and skeletal muscle (SM) and 30-day mortality in patients infected with carbapenem-resistant *K. pneumoniae* (CRKP) in the pulmonary region. Furthermore, we established Cox regression models and a personalized nomogram model to predict the probability of 30-day mortality in these infected patients.

Results: Individuals with high VAT exhibited a higher likelihood of 30-day all-cause mortality (P<0.01) and 30-day mortality due to CRKP infection (P<0.01) compared to those with low VAT. Similar results were observed for TAT. After adjusting for significant comorbidities and other clinical characteristics, Cox regression analysis revealed that male gender (adjusted HR = 4.37; 95% CI = 0.96–19.92, P=0.06), vasopressor use (adjusted HR = 3.65; 95% CI = 1.04–12.85, P=0.04), and VAT (adjusted HR = 1.16; 95% CI = 1.01–1.34, P=0.03) were independent risk factors for 30-day all-cause mortality among these infectious patients.

Conclusion: The study results highlight the significant prognostic value of CT-quantified visceral adipose tissue in patients with CRKP pulmonary infection. Individuals with high VAT are more prone to mortality within 30 days compared to those with low VAT.

Keywords: body composition, carbapenem-resistant *Klebsiella pneumoniae*, mortality, visceral adipose tissue, pulmonary infection

Introduction

Currently, the global prevalence and dissemination of carbapenem-resistant *Klebsiella pneumoniae* (*K. pneumoniae*) infections are on the rise. In China, the detection rate of CRKP reached 27.1% in 2021.[1] According to the China Antimicrobial Surveillance Network (CHINET, http://www.chinets.com/), the prevalence of imipenem *K. pneumoniae* in China has increased from 2.0% in 2005 to 24.8%, while meropenem-resistant *K. pneumoniae* has increased from 2.9% in 2005 to 26.0% in 2023. Among these diverse clinical specimens, more patients with sputum or bronchoalveolar lavage fluid than the bloodstream.[2,3] Meanwhile, mortality rates attributable to carbapenem-resistant *K. pneumoniae* (CRKP) infections vary across continents, with reported figures of 44.82% in Asia, 50.06% in Europe, 46.71% in South America, and 33.24% in North America.[4,5] Due to its widespread transmission, limited effective antibiotics, and elevated treatment

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failure rates, CRKP poses an imminent threat to vulnerable patients and places a substantial burden on global public health systems. Consequently, it has garnered significant attention worldwide.[6] Given the swiftly escalating prevalence and elevated lethality associated with CRKP infection, early identification of prognostic factors for in-hospital 30-day mortality becomes imperative. Implementing effective interventions to mitigate mortality in these infectious patients holds paramount significance.

Based on incomplete data, in 2016, the World Health Organization estimated that over 1.9 billion adults, accounting for 39% of the adult population, were classified as overweight, while 650 million individuals, constituting 13% of the adult population, were categorized as obese. Numerous studies have underscored a robust association between overweight and obesity and the complications, severity, and mortality of infectious diseases, including but not limited to influenza A and Coronavirus Disease 19 (COVID-19).[7,8] Body Mass Index (BMI), the conventional measure, is widely employed to assess overweight and obesity in adults. However, it falls short in distinguishing between skeletal muscle tissue (SM), visceral adipose tissue (VAT), and subcutaneous adipose tissue (SAT). The distribution of muscle tissue and adipose tissue significantly varies by gender and age. Typically, women tend to have higher fat content than men with the same BMI. Additionally, the elderly are prone to having less SM compared to young adults.[9] Abdominopelvic computed tomography (CT) imaging, coupled with noninvasive postprocessing tools, facilitates more accurate and reliable differentiation and quantification of SM, VAT, and SAT. There are differences in cellular composition, morphology, receptor distribution, endocrine function, and metabolic characteristics between visceral adipocytes and subcutaneous adipocytes.[10] VAT encompasses the adipose tissue surrounding human organs, such as the omentum, mesentery, retroperitoneum, and perirenal areas. It serves the vital functions of supporting, stabilizing, and protecting the internal organs of the human body. On the other hand, SAT refers to the adipose tissue located below the dermis and above the fascia. Its primary roles include insulation and energy storage.

Excessive visceral adipose tissue is considered to play a significant role in the onset and progression of metabolic-related diseases, as well as infectious diseases.[11] VAT-to-SAT ratio significantly increased organ failure requiring support treatment and mortality in septic patients.[12] VAT, in contrast with SAT, contributes to adverse clinical outcomes in infectious patients probably by virtue of stronger pro-inflammatory versus anti-inflammatory response, and the delay of the immune response.[12] Also, VAT is a marker of worse clinical outcomes in patients with COVID-19.[13] In addition, our previous research has shown that CT-based body composition analysis is a potent tool for effectively and accurately predicting the clinical outcomes of patients with bloodstream infections (BSI) caused by CRKP.[14] Therefore, we hypothesized that the various types of adipose tissue identified through CT may also be associated with the prognosis of patients experiencing CRKP pulmonary infection. To date, no relevant research has been conducted.

In this study, the main objective was to investigate the correlation between CT-derived body composition (VAT, SAT, TAT, and SM) and 30-day mortality in patients with CRKP pulmonary infection. Additionally, Cox regression models and personalized nomogram models were constructed to predict the likelihood of 30-day mortality in these infected patients. These models aim to assist physicians in evaluating the patient's condition and implementing effective measures to prevent adverse clinical outcomes.

Materials and Methods

Study Design and Patients

This retrospective cohort study was conducted at the First Affiliated Hospital of Wenzhou Medical University, a prominent tertiary and teaching hospital in the southern province of Zhejiang, China. The study focused on patients with CRKP pulmonary infection, confirmed by both etiological evidence and clinical symptoms, and with an available abdominal computed tomography (CT) scan. The data collection spanned from January 1, 2016, to December 31, 2020.

Inclusion criteria encompassed patients whose initial culture of CRKP was sputum or bronchoalveolar lavage fluid during their hospital stay. The diagnosis of CRKP infection was established through a combination of clinical symptoms, signs, clinical laboratory indicators, assessable imaging reports, and progress notes. Abdominopelvic CT images from the 15 days preceding and following the first positive culture of CRKP were considered. Exclusion criteria were applied to patients under 18 years old, those with incomplete clinical data or whose families declined further treatment, and

individuals for whom accurate evaluation of abdominal CT scans was hindered by serious motion artifacts or technical issues (such as limited quantitative visual field of adipose tissue or the use of contrast media).

CRKP was defined as *K. pneumoniae* with a minimum inhibitory concentration (MIC) ≥ 4 mg/L to meropenem, imipenem, and ertapenem, following the guidelines set by the Clinical and Laboratory Standards Institute (CLSI).

Variables and Definitions

Data pertaining to demographic characteristics (age and sex), baseline diseases, illness severity (Charlson comorbidity index and Sequential Organ Failure Assessment (SOFA) Scores), interventions (invasive intervention surgery, mechanical ventilation, vasopressor and renal replacement therapy), laboratory indicators, additional infection sites, concurrent viral or fungal infections, body compositions (SM, VAT, SAT, TAT), antibiotic details, and patient outcomes were meticulously reviewed and collected from electronic medical records for analysis.

The observational onset of the study was defined as the date of the first positive CRKP culture from sputum or bronchoalveolar lavage fluid in the hospital. Laboratory indicators from blood and SOFA scores were recorded within 48 hours before CRKP culture detection. For participants whose weight information was not retrievable due to severe illness, interpolation was used to estimate their weight. Vasopressor, mechanical ventilation, renal replacement therapy, and antibiotic treatment were considered for analysis only if they were maintained for more than 48 hours in the 30 days preceding the onset.

Appropriate initial antibiotic therapy was defined as the administration of at least one active agent for more than 48 hours, based on the antimicrobial susceptibility test of *K. pneumoniae* in vitro. This was typically prescribed by physicians within 3 days after the first episode of CRKP diagnosis. Invasive procedures conducted within one month before or after the onset of infection were categorized as patients undergoing surgery.

Given the prevailing circumstances in China, where families may be reluctant to allow their loved ones outside, and instances where patients discontinued treatment due to worsening conditions and were discharged automatically during hospitalization were classified as death cases.

Assessment of Body Composition

A meticulous examination focused on a singular cross-sectional CT image capturing the intricacies of the third/fourth lumbar (L3/4) intervertebral disk. This analysis aimed to distinguish and measure muscle tissue, subcutaneous fat, and visceral fat through the utilization of a multi-platform semiautomatic software tool (Syngo Volume tool, Siemens Healthcare, Munich, Berlin, Germany).[15] The body composition data derived from the L3-L5 level was identified as exhibiting the strongest correlation with overall body fat tissue and muscle mass.[16,17] The segmentation and computation of specific regions of interest (ROI) relied on standardized Hounsfield units (HU) thresholds, with 40 to 100 hU designated for muscle tissue and −190 to −30 hU for fat tissue (Figure 1).[18]

Proficient CT planes were systematically delineated by two experienced physicians independently. Simultaneously, the regions of interest (ROI) in CT images were manually demarcated and examined using a semi-automatic software tool. For accuracy evaluation, two measurements were acquired for each patient, and the mean values were documented.

Statistical Analyses

Statistical analyses of the data were carried out using R version 4.1.2 and IBM SPSS Statistics 25.0. Continuous variables were presented as either the mean ± standard deviation (for normally distributed data) or the median and interquartile range (for non-normally distributed data), and comparisons were made using Student's *t*-test or Mann–Whitney *U*-test, respectively. Categorical variables were assessed using the chi-square test or Fisher's exact test, and results were expressed as frequencies and percentages.

All statistical tests were two-tailed, and a significance level of $P < 0.05$ was considered statistically significant. The impact of various variables on the 30-day survival of patients was evaluated using log-rank survival analysis, and a Cox regression model was established. Variables with $P < 0.1$ were included in the regression model.

Optimal cut-off points for TAT and VAT were determined through Receiver Operating Characteristic (ROC) curve analysis. Additionally, a nomogram predicting 30-day mortality was constructed based on the results of univariate

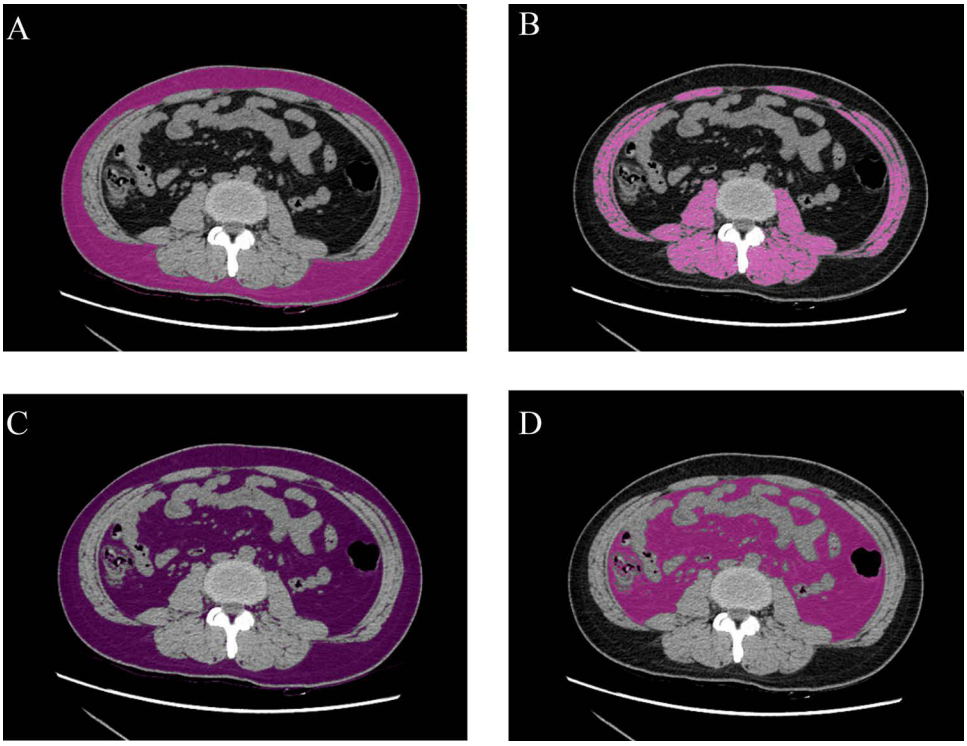

Figure 1 Abdominal CT image post-processing with LIFEx. Subcutaneous adipose tissue (**A**); Skeletal muscle (**B**); Total adipose tissue (**C**); Visceral adipose tissue (**D**).

analysis and crucial clinical prognostic factors. This nomogram aimed to calculate the 30-day survival probability for patients with CRKP pulmonary infection.

Results

Patient Characteristics

Based on the specified inclusion and exclusion criteria, a total of 89 eligible participants were recruited from the First Affiliated Hospital of Wenzhou Medical University, spanning from January 1, 2016, to December 31, 2020. The cohort comprised 71 men and 18 women. Table 1 presents the demographic characteristics, clinical details, laboratory indicators, body composition parameters, and treatment regimens.

Significant distinctions were observed in SOFA scores, vasopressor usage, mechanical ventilation utilization, total adipose tissue, visceral adipose tissue, and subcutaneous adipose tissue between the survival and mortality subgroups of patients with CRKP pulmonary infection. Regarding antibiotic therapy, 13 participants received polymyxin B-based treatment, while 52 participants underwent tigecycline-based combination therapy; however, no significant differences were noted between the survival and mortality subgroups in this context.

Impact of Body Composition on Survival

Among the 89 patients assessed with abdominal CT planes at the L3/4 intervertebral disk, significant differences were observed in Total Adipose Tissue (TAT) ($P = 0.002$), Visceral Adipose Tissue (VAT) ($P < 0.001$), and Subcutaneous Adipose Tissue (SAT) ($P = 0.022$) between the survival and mortality groups (Table 1). The multivariate regression model investigating the association between body compositions and 30-day mortality indicated that lower TAT and lower VAT were associated with a more favorable clinical outcome (Table 2), adjusting for cardiovascular disease, vasopressor use, and SOFA scores. However, skeletal muscle areas did not exhibit statistically significant differences in the regression model between the two subgroups.

Furthermore, an analysis of the association between adipose tissue and clinical prognosis using the Log rank test revealed that high VAT was associated with a higher risk of death compared to low VAT in both 30-day all-cause mortality ($P < 0.01$) and 30-day mortality due to CRKP infection ($P < 0.01$), as depicted in Figure 2. Similar results were

Table 1 Comparative Analysis of Clinical Features Between Survivors and Non-Survivors of CRKP Pulmonary Infection

Demographic Data	**Survival (N=63)**	**Non-survival (N=26)**	**P value**
Age	66.0 (53.5–72.5)	67.0 (51.2–70.8)	0.620
Male	47 (74.6%)	24 (92.3%)	0.059
Co-morbidities			
Cardiovascular disease	3 (4.8%)	5 (19.2%)	0.044
COPD	3 (4.8%)	4 (15.4%)	0.187
Moderate to severe chronic kidney disease	4 (6.3%)	2 (7.7%)	0.818
Diabetes	10 (15.9%)	7 (26.9%)	0.228
Central nervous system disease	13 (20.6%)	7 (26.9%)	0.518
Cancer	7 (11.1%)	3 (11.5%)	0.954
Severity of illness			
Charlson comorbidity index	1.0 (0.0–2.0)	1.0 (0.0–2.8)	0.316
SOFA scores	6.0 (4.0–8.0)	6.0 (6.0–10.0)	0.017
Interventions			
Vasopressor use	34 (54.0%)	23 (88.5%)	0.002
Mechanical ventilation use	52 (82.5%)	26 (100.0%)	0.023
RRT use	10 (15.9%)	8 (30.8%)	0.112
Surgery	34 (54.0%)	11 (42.3%)	0.317
Laboratory indicators			
WBC (10^9/L)	9.2 (7.1–12.3)	11.1 (8.9–16.4)	0.022
Platelet (10^9/L)	179.0 (125.0–323.0)	161.5 (130.5–230.0)	0.386
Total bilirubin (μmol/L)	15.0 (10.5–24.0)	16.5 (10.2–25.5)	0.462
Creatinine (umol/L)	58.0 (44.5–92.0)	93.5 (74.8–160.2)	0.005
U*rea nitrogen (mmol/L)*	9.4 (5.8–12.9)	11.9 (7.6–20.8)	0.016
CRP (mg/L)	80.0 (42.9–90.0)	90.0 (48.8–90.0)	0.339
PCT (ng/mL)	0.5 (0.2–2.7)	1.1 (0.7–1.9)	0.076
Other infection site			
BSIs	3 (4.8%)	3 (11.5%)	0.352
Abdominal	19 (30.2%)	6 (23.1%)	0.499
Urinary	5 (7.9%)	0 (0.0%)	0.316
Combined viral infection	1 (1.6%)	1 (3.8%)	0.501

(*Continued*)

Table 1 (Continued).

Demographic Data	Survival (N=63)	Non-survival (N=26)	P value
Body compositions			
Total adipose tissue	17.8 (13.8–27.2)	28.6 (23.3–34.4)	0.002
Visceral adipose tissue	8.9 (6.2–13.3)	15.8 (12.3–17.8)	<0.001
Subcutaneous adipose tissue	9.5 (6.5–13.3)	12.9 (9.8–14.8)	0.022
Skeletal muscle	6.1 (2.7–8.6)	8.0 (4.6–10.2)	0.067
Details of antibiotics			
PMB-based therapy	7 (11.1%)	6 (23.1%)	0.146
TGC-based therapy	35 (55.6%)	17 (65.4%)	0.392
Other antibiotics therapy	29 (46.0%)	7 (26.9%)	0.095
Appropriate initial antibiotics therapy	37 (58.7%)	15 (57.7%)	0.928

Abbreviations: SOFA, Sequential Organ Failure Assessment Scores; RRT, renal replacement therapy; CRP, C-Reactive protein; PCT, procalcitonin; PMB-based therapy, polymyxin B-based combination therapy; TGC-based therapy, tigecycline-based combination therapy; Other antibiotics therapy: aminoglycosides, fosfomycin, carbapenem, etc.

Table 2 Association Between Body Compositions and 30-Day Mortality

	Univariate Analysis	*p* value	Multivariate Analysis	*p* value
	HR		HR	
TAT	1.04 (1.01, 1.07)	0.006	1.04 (1.01, 1.07)	0.013
VAT	1.09 (1.04, 1.15)	<0.001	1.09 (1.04, 1.16)	0.002

Note: The multivariate model was adjusted for cardiovascular disease, vasopressor use and SOFA score.

observed for TAT. The optimal cut-off values for high-VAT and high-TAT were 11.59 and 22.1, respectively, for 30-day all-cause mortality. Meanwhile, the optimal cut-off values for high-VAT and high-TAT areas were 11.57 and 22.62, respectively, for 30-day mortality due to CRKP infection.

Risk Factors for 30-Day Mortality

After adjusting for significant comorbidities and other distinct clinical characteristics, Cox regression analysis revealed that male (adjusted HR = 4.37; 95% CI = 0.96–19.92, $P = 0.06$), the use of vasopressors (adjusted HR = 3.65; 95% CI = 1.04–12.85, $P = 0.04$), and VAT (adjusted HR = 1.16; 95% CI = 1.01–1.34, $P = 0.03$) independently constituted risk factors for 30-day all-cause mortality among this cohort of infectious patients (Table 3). Utilizing the outcomes of multivariate Cox regression analysis and variables closely associated with clinical prognosis, nomogram models were developed to visually estimate the 30-day survival probability for patients with pulmonary infection caused by CRKP. By quantifying various risk factors to predict the likelihood of clinical events, the nomogram transforms intricate regression models into visual graphs, facilitating a more convenient and practical evaluation of patient prognosis. Significantly, the SOFA scores and VAT play crucial roles in predicting both 30-day all-cause mortality and 30-day mortality specifically attributed to CRKP infection in these patients with CRKP pulmonary infection (Figures 3 and 4). The C-index of the nomogram was determined to be 0.771 and 0.756, respectively.

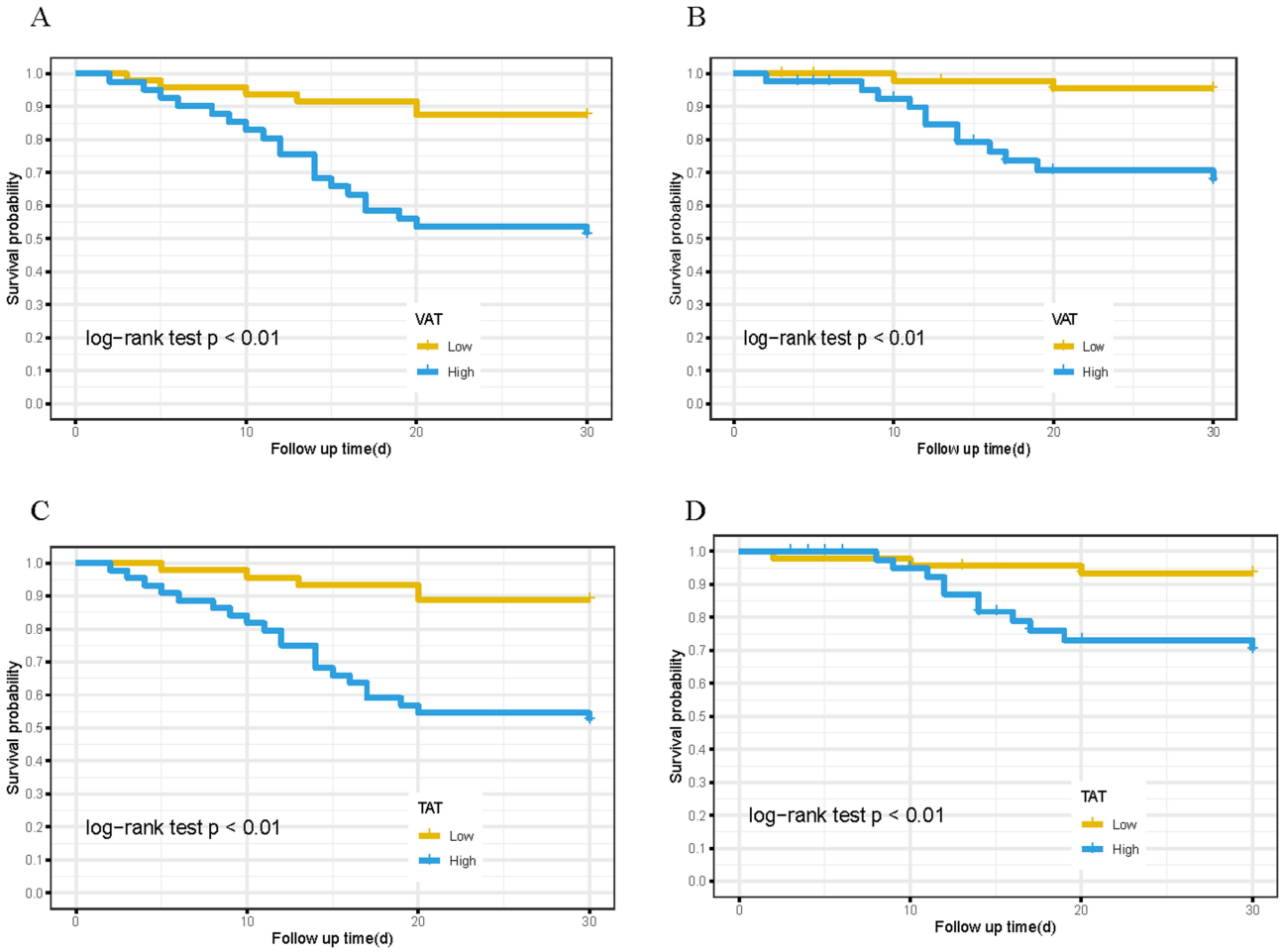

Figure 2 The Log rank test between high-VAT and low-VAT and 30-day all-cause mortality (**A**) and 30-day mortality owing to CRKP pulmonary infection (**B**). The Log rank test between high-TAT and low-TAT and 30-day all-cause mortality (**C**) and 30-day mortality owing to CRKP pulmonary infection (**D**).

Discussion

Currently, CRKP pulmonary infection is widely acknowledged as one of the most pressing global health challenges, posing a substantial threat to human health due to its high morbidity and fatality rate. This has garnered significant

Table 3 Univariate and Multivariate COX Regression Analysis of 30-Day Mortality of Patients with CRKP Pulmonary Infection

Variables	Crude HR	P value	Adjusted HR	P value
Age	0.99 (0.97, 1.02)	0.65		
Male	3.56 (0.84, 15.09)	0.08	4.37 (0.96, 19.92)	0.06
Cardiovascular disease	2.96 (1.12, 7.88)	0.03	1.70 (0.59, 4.89)	0.33
COPD	2.57 (0.88, 7.46)	0.08		
Moderate to severe chronic kidney disease	1.02 (0.24, 4.30)	0.98		
Diabetes	1.70 (0.72, 4.05)	0.23		
Central nervous system disease	1.28 (0.54, 3.05)	0.57		

(*Continued*)

Table 3 (Continued).

Variables	Crude HR	P value	Adjusted HR	P value
Cancer	1.07 (0.32, 3.55)	0.92		
Charlson comorbidity index	1.08 (0.89, 1.32)	0.44		
SOFA	1.13 (1.02, 1.25)	0.01	1.08 (0.96, 1.22)	0.19
Vasopressor use	5.34 (1.60, 17.80)	<0.01	3.65 (1.04, 12.85)	0.04
RRT use	1.91 (0.83, 4.40)	0.13		
Total adipose tissue	1.04 (1.01, 1.07)	<0.01	0.98 (0.90, 1.06)	0.55
Visceral adipose tissue	1.09 (1.04, 1.15)	<0.01	1.16 (1.01, 1.34)	0.03
Skeletal muscle	1.10 (0.99, 1.23)	0.08		
Subcutaneous adipose tissue	1.05 (0.99, 1.10)	0.09		

attention from healthcare professionals. However, the risk factors related to mortality of CRKP bloodstream infections were partly varied and contradictory. Based on the present proof-of studies, older age, severe underlying disease, renal dysfunction, Pitt bacteremia score, and SOFA scores were deemed to be the independent prognostic factors of the CRKP BSI.[14,19,20] There were relatively few previous studies on the prognostic factors of pneumonia owing to CRKP infection. Treatment failure for pulmonary infection was regarded as the independent risk factor for all-cause in-hospital mortality.[21] Consequently, there is an urgent need for early and precise evaluation of the risk factors contributing to mortality among infected patients. Implementing targeted strategies to reduce fatality is of paramount importance. Notably, existing research suggests that CT-quantified visceral adipose tissue is recognized as a significant risk factor for more severe complications and higher mortality in patients with COVID-19.[13,22] Moreover, CT-derived body composition also provides a reliable alternative for physicians to assess the nutritional status, especially for these severely infected patients who lack weight due to their extremely poor physical condition. These severely infected hospitalized patients undergo abdominal CT as it is deemed necessary for their medical condition. The utilization of

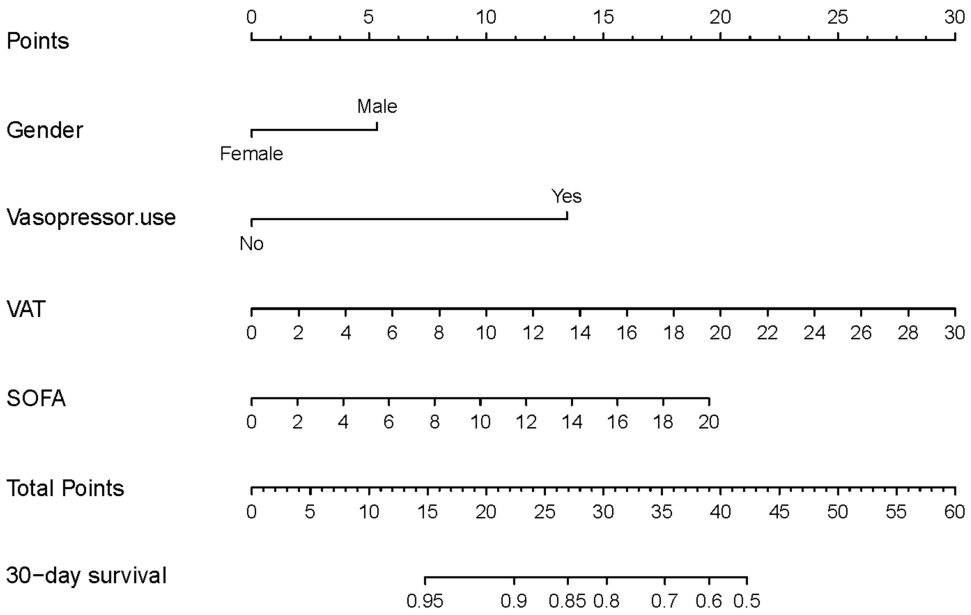

Figure 3 The nomogram to predict the 30-day all-cause mortality.

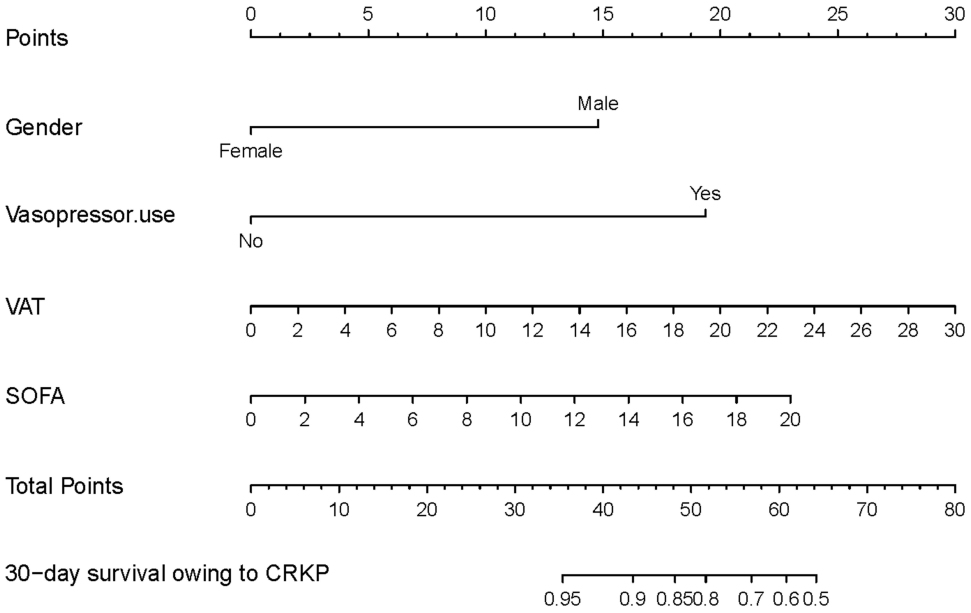

Figure 4 The nomogram to predict the 30-day mortality owing to CRKP pulmonary infection.

noninvasive postprocessing tools during the procedure ensures there is no additional radiation exposure or associated costs. As severely infected patients are in a state of consumption, the abdominopelvic CT images from the 15 days preceding and following the research starting point, could accurately reflect the current nutritional status of patients. To date, our study is the first to examine the relationship between body components derived from abdominal CT scans and the prognosis of patients with pulmonary infections caused by CRKP.

In this study, we delved into the association between CT-quantified abdominal visceral and subcutaneous adipose tissue, total fat area, and muscle tissue with 30-day clinical outcomes in patients afflicted with pulmonary infections caused by CRKP. Baseline comparisons of clinical features and results from univariate Cox regression analysis indicated that higher VAT increased the risk of 30-day all-cause mortality. Furthermore, after adjusting for crucial comorbidities and differences in baseline characteristics, multivariate Cox regression analysis and the construction of a nomogram for 30-day mortality in patients with CRKP pulmonary infection unveiled that VAT retained its predictive significance for prognosis. Moreover, our research revealed that VAT was a more significant predictor of both 30-day all-cause mortality and mortality specifically due to CRKP infection among these patients, as opposed to TAT. This finding contrasts with the earlier study.[14] Elevated VAT was identified as a risk factor for mortality in these infected patients. This heightened risk could be attributed to a variety of factors, including chronic inflammatory status, delayed immune response, and the potential role of adipose tissue as a reservoir for viruses and bacteria.

Adipose tissue stands as a crucial and distinctive structural component of the human body, playing dual roles in both body composition and energy storage. It additionally serves as a significant endocrine organ, exerting influence over insulin sensitivity, blood pressure, fibrinolytic activity, inflammatory response, and immunity. In individuals with obesity, a condition characterized by heightened body fat, a state of low systemic inflammation often prevails. This inflammatory state contributes to the onset of metabolic diseases. Concurrently, the occurrence and progression of these metabolic disorders also impact the immune response of patients, rendering the immune system of infected individuals more susceptible to challenges.[22–24] Previous studies have revealed disparities in cell composition, morphology, receptor distribution, endocrine function, and metabolic characteristics between visceral fat cells and subcutaneous fat cells. Specifically, VAT has been identified as a dyslipidemic and atherogenic fat depot, exhibiting greater insulin resistance, increased metabolic activity, and heightened sensitivity to lipolysis when compared to subcutaneous fat cells.[25] VAT has been implicated in promoting the onset and progression of metabolic syndrome, elevating the risk of conditions such as hyperlipidemia, type 2 diabetes mellitus, and cardiovascular and cerebrovascular diseases. In contrast, SAT does not exert

a significant impact on the development of these diseases. Additionally, the accumulation of excess visceral fat is recognized as a crucial risk factor for the development of atherosclerosis and cardiovascular diseases,[26] leading to slower recovery and higher overall mortality. Patients with type 2 diabetes mellitus or hyperlipidemia often present a predisposition to other metabolism-related diseases. This propensity has been observed to contribute to unfavorable outcomes in patients with CRKP pulmonary infections.

Moreover, research pertaining to COVID-19 has revealed a close association between excess VAT and delayed immune response, as well as chronic systemic inflammation within pathophysiological pathways. Notably, there exist differences in protein expression between visceral and subcutaneous adipocytes, leading to the synthesis and secretion of diverse types and levels of cytokines. Visceral fat tissue, characterized by a richer arterial supply and nerve distribution, contains a higher density of lymphocytes and white blood cells. It also exhibits heightened secretion of pro-inflammatory factors, including interleukin-6 (IL-6), interleukin-8 (IL-8), tumor necrosis factor-α (TNF-α), monocyte chemoattractant protein-1 (MCP-1), vascular endothelial growth factor (VEGF), and C-reactive protein (CRP).[27,28] These inflammatory mediators, integral to 271 biological processes such as bacterial molecular response, tumor necrosis factor response, and lipopolysaccharide response, exhibit higher expression levels in VAT compared to their lower expression in SAT.[10] Simultaneously, visceral adipose tissue releases elevated levels of leptin, a hormone associated with airway reactivity. This release contributes to the creation of an unfavorable inflammatory environment, ultimately leading to the disruption of the immune response.[29] Therefore, the accumulation of VAT sustains a pro-inflammatory state, fostering an exaggerated inflammatory response and intensifying the severity of pulmonary infections in patients with CRKP. This, in turn, significantly impacts the prognosis of these patients. Additionally, VAT plays a role in the overactivation of the complement system and contributes to the development of chronic inflammation. Furthermore, existing studies have indicated that obesity can compromise the response of CD^{8+} memory T cells to infection in patients with influenza virus or COVID-19, leading to more severe pulmonary disease and higher mortality.[30] In conclusion, individuals with elevated VAT levels contribute to increased pro-inflammatory cell levels and diminished immune responses through multiple pathways. This ultimately leads to unfavorable outcomes in patients with CRKP lung infections.

Moreover, some previous studies have revealed that excessive visceral adipose tissue may serve as a significant reservoir for microorganisms such as *Mycobacterium tuberculosis*, influenza A virus, adenovirus, and others. VAT has the potential to extend the shedding time of these microorganisms and enhance cytokine activation. This, in turn, contributes to higher mortality rates in patients with CRKP pulmonary infections, particularly in those with high VAT. Additionally, visceral adiposity can impede diaphragmatic excursion and elevate airway resistance, thereby impairing breathing and mechanical ventilation. These factors collectively exacerbate the course of adverse outcomes.

This study has several acknowledged limitations. Firstly, it is a single-center retrospective study with a relatively small sample size. Secondly, the exclusion of patients with CRKP pulmonary infection who did not undergo abdominal CT scans or those with artifacts on abdominal CT may introduce potential sampling bias and limit the generalizability of the findings. Lastly, patients with CRKP infection typically present with underlying diseases and comorbidities, where advanced age and severe comorbidities may contribute to the deterioration of the condition, thereby increasing the risk of all-cause mortality.

Despite these limitations, it is crucial to note that this study is the first to explore the relationship between CT-quantified body composition and prognosis in patients with CRKP infection. The development of the nomogram provides a valuable tool for clinicians to assess the prognosis of severely infected individuals and implement effective interventions to improve survival. It is anticipated that future research in this area will involve larger, high-quality prospective studies to further validate and expand upon these findings.

Conclusion

The findings of this study underscore the significance of CT-quantified visceral adipose tissue in prognostically evaluating patients with CRKP pulmonary infection. Patients with high VAT levels exhibit a heightened susceptibility to mortality within 30 days compared to those with low VAT levels, whereas SAT and SM were not found to be predictive in this context. Moreover, the study identified male gender, vasopressor use, and elevated VAT as independent risk factors for 30-day all-cause mortality in these infectious patients.

Data Sharing Statement

All data generated or analyzed during this study are fully incorporated within this article. For any additional inquiries, please feel free to contact the corresponding author.

Ethics Approval and Consent to Participate

This study was approved by the recommendations of the Ethics Committee in Clinical Research of the First Affiliated Hospital of Wenzhou Medical University (Acceptance Number: KY2021-R096). The Ethics Committee waived the need for informed consent because it was an observational study primarily focused on microorganisms and without any treatments on patients, and all personal information of patients was correctly anonymized and de-identified during data collection. All experimental techniques in this work properly followed relevant laws, institutional guidelines, and the ethical principles specified in the Helsinki Declaration.

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Disclosure

The authors declare that they have no competing interests in this work.

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