Comparison of CURB-65 and qSOFA Combined with Serum Markers and HRCT in Predicting Mortality in AIDS with *Pneumocystis jirovecii* Pneumonia

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ABSTRACT

Objective: To evaluate and compare the clinical predictive value of the CURB-65 and qSOFA scores, combined with serum markers and HRCT scores, in assessing mortality risk in Acquired Immunodeficiency Syndrome (AIDS) patients with *Pneumocystis jirovecii* pneumonia (PJP).

Study Design: Descriptive analytical study.

Place and Duration of the Study: Department of Respiratory and Critical Care Medicine, Beijing Youan Hospital, Capital Medical University, Beijing, China, from January to December 2022.

Methodology: Patients with AIDS and PJP were divided into two groups based on prognosis: Non-survivors (n = 35) and survivors (n = 85). Clinical data such as WBC count, CRP, PCT, $CD4^+$ T lymphocyte count, and so on were collected. CURB-65, qSOFA, and HRCT scores were calculated. Independent risk factors for mortality were identified using logistic regression analysis, and their clinical predictive value was assessed using the area under the ROC curve (AUC).

Results: The non-survivors group had longer mechanical ventilation duration, higher rate of tracheal intubation, WBC count, CRP, PCT, CURB-65 score, qSOFA score, and HRCT score, but lower $CD4^+$ T lymphocyte count than the survivors group ($p < 0.05$). Univariate and multivariate logistic regression identified WBC count 1.15×10^9/L, CURB-65 score (14), qSOFA score (11.02), and HRCT score (1.37) as independent risk factors for mortality in AIDS patients with PJP ($p < 0.05$). ROC analysis showed that CURB-65 had better predictive value than qSOFA for individual indicators ($p < 0.001$), and CURB-65 + HRCT + WBC outperformed qSOFA+ HRCT + WBC for combined indicators ($p < 0.001$).

Conclusion: The combination of the CURB-65 score, HRCT score, and WBC count may effectively assess disease severity and mortality risk in AIDS patients with PJP.

Key Words: *Acquired immunodeficiency syndrome, Pneumocystis jirovecii pneumonia, CURB-65 score and qSOFA score, Serum markers, HRCT score, Mortality prediction*.

How to cite this article: Wang S, Xue Y. Comparison of CURB-65 and qSOFA Combined with Serum Markers and HRCT in Predicting Mortality in AIDS with *Pneumocystis jirovecii* Pneumonia. *J Coll Physicians Surg Pak* 2025; **35(03)**:292-296.

INTRODUCTION

According to data from 2020, there were 37.7 million people living with AIDS worldwide. The number of new cases continues to rise at a rate of 1.5 million per year.[1,2] In China, over 850,000 individuals have been diagnosed with AIDS.[3] While most AIDS patients can achieve HIV viral load negativity and maintain $CD4^+$ T lymphocyte counts above 200 cells/uL after antiretroviral therapy, they remain vulnerable to opportunistic infections and malignant tumours, which can shorten their lifespan.

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Received: September 19, 2024; Revised: January 20, 2025; Accepted: February 18, 2025
DOI: https://doi.org/10.29271/jcpsp.2025.03.292

Pneumocystis jirovecii pneumonia (PJP) is a common respiratory opportunistic infection with a high incidence and mortality rate in AIDS patients,[4-6] with an incidence as high as 22.4%.[7] The overall mortality rate is 84% for patients requiring mechanical ventilation or ICU admission due to respiratory failure.[8] Therefore, it is crucial to use objective digital evaluation indicators for early warning and to predict the outcome of AIDS patients with PJP to guide clinical treatment.

A retrospective study from Beijing Ditan Hospital showed that the 180-day mortality rate in AIDS patients with PJP can be predicted using the CURB-65, PSI, and APACHE II scores.[9] However, the PSI and APACHE II scores involve multiple complex calculations, which limit their clinical applicability. In contrast, the qSOFA score is simple and easy to calculate, enabling rapid assessment of disease severity and prognosis. However, no studies have yet explored the use of the qSOFA score to predict mortality risk in AIDS patients with PJP.

The aim of this study was to assess the disease severity and mortality risk in AIDS patients with PJP from multiple perspec-

tives, including the CURB-65 score, qSOFA score, serum markers, and chest imaging with HR. The subsequent aim was to compare the predictive value of these scores to identify the most effective combination for guiding clinical treatment.

METHODOLOGY

The study participants included 120 patients with AIDS and PJP who were admitted to Beijing Youan Hospital, affiliated with Capital Medical University, Beijing, China, from January to December 2022. Inclusion criteria were age ≥18 years; HIV-1/2 antibody positive; positive PJP-qPCR testing of sputum, bronchoalveolar lavage fluid, or lung biopsy tissue. Exclusion criteria were patients with concomitant infections in other parts of the body or infections caused by other pathogens, patients with incomplete clinical data affecting scoring, patients whose prognosis assessment was influenced by refusal or abandonment of treatment. The study was conducted with the approval of the Hospital's Medical Ethics Committee (No: LL-2022-045-K).

This study investigated and compared the predictive value of the CURB-65 score and qSOFA score, combined with venous blood test results and chest HRCT scores, in predicting mortality in patients with AIDS and PJP. The electronic medical record system was utilised to collect relevant clinical data on the participants, including their gender, age, duration of hospitalisation, whether they had undergone tracheal intubation, the length of mechanical ventilation, $CD4^+$T lymphocyte count, WBC, CRP, PCT, conscious status, GCS score, BUN, respiratory rate, blood pressure, and HRCT results. The participants were then categorised into two groups: The non-survivors group and the survivors group, based on their prognosis. Using information gathered from the first day of hospitalisation, the CURB-65, qSOFA, and HRCT scores were calculated.

The CURB-65 score consists of five parameters including consciousness disorders, BUN >7 mmol/L, respiratory rate ≥30 breaths/min, systolic blood pressure <90 mmHg or diastolic blood pressure ≤60 mmHg, and age ≥65 years. Each parameter is assigned 1 point and corresponds to different systems, including the central nervous system, renal system, respiratory system, circulatory system, and basic age. The qSOFA score includes GCS score <13, respiratory rate ≥22 breaths/min, and systolic blood pressure ≤100 mmHg. Each parameter is assigned 1 point, reflecting the central nervous, respiratory, and circulatory systems. For the HRCT score, three observation planes—the upper margin of the aortic arch, the tracheal prominence, and 1 cm above the right diaphragm—were selected to represent the upper, middle, and lower lung fields, respectively. In each plane, the percentage of ground-glass opacity, reticular shadow, and honeycomb shadow was assessed and given a semi-quantitative score: 0 for no change; 1 for 1-25%, 2 for 26-50%, 3 for 51-75%, and 4 for 76-100%. The HRCT score was then calculated by summing the points for each plane.

According to a previous study, the AUC of the constructed prediction model was 0.80 (0.796).[9] Therefore, in this study, the AUC predicted by the CURB-65 score or qSOFA score, combined with venous blood test results and chest HRCT score, was considered clinically significant at 0.80. As previously documented in the literature, the mortality rate of AIDS combined with PJP was approximately 20%.[10] This estimation was derived using the following parameters: $\alpha = 0.05$, power = 0.80, with the test benchmark being an AUC = 0.60. The sample size was calculated using PASS 2021 software, which determined that at least 20 cases should be included in the non-survivors group and at least 80 cases in the survivors group.

The normality of continuous variables was assessed using the Kolmogorov-Smirnov test, with a p-value ≥0.05 indicating normal distribution. Statistical comparisons between the two groups were carried out using the two-tailed Student's t-test, and normally distributed continuous variables were expressed as means ± standard deviations (mean ± SD). For non-normally distributed continuous variables, a comparison between the two groups was conducted using the Mann-Whitney U test, with results reported as the median and interquartile range [IQR (P25, P75)]. Categorical variables were analysed using the chi-squared test or Fisher's exact test and were presented as n (%). Univariate logistic regression analysis was performed on variables with statistical differences between the survivors and non-survivors groups, and those with significance were further analysed using multivariate logistic regression analysis to identify independent risk factors for mortality in AIDS patients with PJP. The AUC with a 95% confidence interval (CI) was used to determine the optimal diagnostic thresholds corresponding to the maximum Youden's index for WBC, HRCT score, and combined CURB-65 score or qSOFA score detection. The AUC was also employed to evaluate the clinical predictive value of these factors for the mortality risk in AIDS patients with PJP. Statistical significance was defined as a two-sided p-value of less than 0.05.

RESULTS

This study involved 120 participants, with 85 (70.8%) in the survivors group and 35 (29.2%) in the non-survivors group. No significant differences were found between the two groups in terms of age, gender, or duration of hospitalisation ($p > 0.05$). The non-survivors group had a significantly higher rate of tracheal intubation; longer mechanical ventilation duration; and elevated levels of WBC, CRP, PCT, CURB-65 score, qSOFA score, HRCT score, but lower $CD4^+$T lymphocyte count than the survivors group ($p < 0.05$, Table I).

Indicators with significant differences between the survivors and non-survivors' groups, including WBC count, CURB-65 score, qSOFA score, and HRCT score, were analysed using univariate logistic regression analysis. Multivariate logistic regression analysis showed that WBC count, CURB-65 score, qSOFA score, and HRCT score were independent risk factors for mortality in AIDS patients with PJP ($p < 0.05$, Table II).

Table I: Characteristics of survivors group and non-survivors group.

Variables	Survivors group (n = 85)	Non-survivors group (n = 35)	$t/Z/\chi^2$	p-value
Age (years)	43.61 ± 13.61	49.26 ± 14.76	-1.947	0.056◇
Male (n,%)	79 (92.9)	34 (97.1)	0.797	0.372◇
Tracheal intubation (n,%)	0 (0.0)	30 (85.7)	97.143	<0.001◇
Duration of mechanical ventilation (days)	0 (0, 0)	6 (2, 12.5)	-9.682	<0.001▲
Duration of hospitalisation (days)	14 (11, 20)	15 (5.5, 23)	-0.659	0.51▲
$CD4^+$ T lymphocyte (/uL)	34 (19, 58)	17 (6.5, 29)	-3.006	0.003▲
WBC count (×10^-9/L)	5.06 (3.48, 7.59)	8.15 (4.99, 11.7)	-3.014	0.003▲
CRP (mg/L)	34.42 (10.52, 67.19)	61.44 (30.24, 91.54)	-2.338	0.019▲
PCT (ng/mL)	0.05 (0.05, 0.2)	0.35 (0.12, 3.21)	-5.642	<0.001▲
CURB-65 score (points)	0 (0, 0)	2 (1.5, 3)	-7.929	<0.001▲
qSOFA score (points)	0 (0, 0)	1 (1, 2)	-6.853	<0.001▲
HRCT score (points)	7 (4, 9)	10 (6, 12)	-4.208	<0.001▲

Note: ◇Independent samples t-test, ▲Mann-Whitney U test, ◇Chi-square test.

Table II: Univariate and multivariate logistic regression analysis of independent risk factors of mortality risk for AIDS combined with PJP.

Variables	Univariate OR (95% CI)	Univariate p-value	B	SE	Wald χ^2	Multivariate OR (95% CI)	Multivariate p-value
Tracheal intubation (n,%)	2.75E + 10 (0~.)	0.997NS					
Duration of mechanical ventilation (days)	3.50E + 07 (0~.)	0.983NS					
$CD4^+$ T lymphocyte (/uL)	0.994 (0.986~1.003)	0.186NS					
WBC count (x10~9/L)	1.152 (1.055~1.258)	0.002**	0.222	0.098	5.103	1.248 (1.030~1.513)	0.024*
CRP (mg/L)	1.008 (0.999~1.016)	0.071NS					
PCT (ng/mL)	1.103 (0.997~1.221)	0.058NS					
CURB-65 score (points)	14.005 (5.223~37.558)	<0.001***	3.202	0.852	14.121	24.586 (4.627~130.626)	<0.001**
qSOFA score (points)	11.024 (4.464~27.223)	<0.001***	2.917	1.024	8.11	18.477 (2.483~137.521)	0.004**
HRCT score (points)	1.371 (1.173~1.602)	<0.001***	0.374	0.175	4.586	1.453 (1.032~2.046)	0.032*

*Univariate and multivariate logistic regression analysis. NS: Non-significant, *: p <0.05, **: p <0.01, ***: p <0.001.*

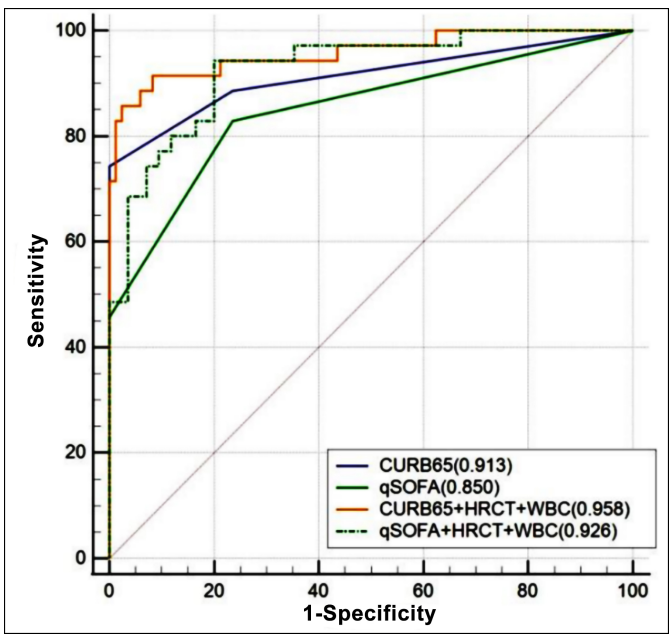

Figure 1: ROC curve of independent risk factors of mortality risk predicting AIDS combined with PJP.

ROC curve showed that in predicting mortality risk in AIDS patients with PJP, the AUC for the CURB-65 score was 0.913 (cut-off >1 point, sensitivity 74.29%, specificity 100%); for the qSOFA score, it was 0.850 (cut-off >0 points, sensitivity 82.86%, specificity 76.47%); for the combined CURB-65, HRCT, and WBC count, it was 0.958 (cut-off >0.49 points, sensitivity 85.71%, specificity 97.65%); and for the combined qSOFA, HRCT, and WBC count, it was 0.926 (cut-off >0.15points, sensitivity 94.29%, specificity 80%). The ROC analysis revealed that CURB-65 score had better predictive value than the qSOFA score for individual indicators (AUC 0.913 *vs.* 0.850, p <0.001). For combined indicators, CURB-65 + HRCT + WBC outperformed qSOFA + HRCT + WBC (AUC 0.958 *vs.* 0.926, p <0.001, Figure 1).

DISCUSSION

Patients with AIDS have compromised immune systems and are more vulnerable to opportunistic infections. The most common, dangerous, and lethal respiratory infection among them is PJP. Due to the high mortality rate in AIDS patients with PJP, early identification and assessment of disease severity, and timely initiation of accurate treatment are particularly important.

This study showed that the CURB-65 score, qSOFA score, HRCT score, and WBC count were independent risk factors for mortality in AIDS patients with PJP. The CURB-65 score had previously been identified as an independent risk factor for predicting the 180-day mortality risk in patients with AIDS and PJP.[9] The finding of the present study was consistent with previous result and suggested an optimal cut-off value of >1 point for the CURB-65 score. Previous findings showed that the 90-day mortality in PJP patients was independently associated with the SOFA score at admission.[11,12] However, no studies examined the correlation between the risk of death from PJP and the qSOFA score. This study filled this gap suggesting that the qSOFA score

was an independent risk factor for mortality in AIDS patients with PJP, with an AUC value of 0.850. A multi-centre retrospective study revealed that the extent of ground-glass opacities on CT images was significantly greater in AIDS patients.[13] The severity of HRCT ground-glass opacities in the chest was associated with the prognosis of PJP.[14] The HRCT score was primarily used for semi-quantitative assessment of the severity of interstitial lung disease.[15] Therefore, the authors attempted to explore the correlation between the HRCT score and the risk of mortality in AIDS patients with PJP from an imaging perspective and found that the HRCT score was also an independent risk factor for mortality in these patients. This conclusion was similar to the previous studies. This could be explained by the fact that Pneumocystis primarily adheres to the surface of Type I alveolar epithelial cells, leading to lung injury and gas exchange disorders due to host inflammatory responses.[16] As a result, it typically appears as diffuse ground-glass opacities on imaging, occasionally accompanied by mosaic patterns and irregular air spaces.[17-19]

In this study, ROC analysis revealed that the CURB-65 score provided superior predictive value compared to the qSOFA score as an individual indicator, while the CURB-65 score + HRCT score + WBC count demonstrated better performance than the qSOFA score + HRCT score + WBC count as a combined indicator.

A review of 22 studies, involving a total of 25,846 participants, suggested that the qSOFA score showed superior specificity in predicting ICU admissions, whereas the CURB-65 score exhibited superior sensitivity for predicting mortality.[20] Research conducted by Guo *et al*. indicated that the qSOFA score was less effective than the CURB-65 score in predicting mortality in CAP.[21] The CURB-65 score is a reliable tool for identifying high-risk AIDS patients with PJP who require intensive management. The CURB-65 score includes additional parameters, such as kidney function and age classification, making it a more comprehensive and objective assessment of the patient's overall condition when compared to the qSOFA score. Consistent with previous studies, the present study confirmed that the CURB-65 score, as well as the CURB-65 score + HRCT score + WBC count, were more effective for predicting mortality in AIDS patients with PJP. When compared based on AUC values, the latter demonstrated superior predictive efficacy.

The CURB-65 score + HRCT score + WBC count encompassed the severity of multi-system organ damage, a semi-quantitative assessment of the severity of chest imaging, and a quantitative evaluation of the degree of infection, thus providing a more comprehensive assessment. A rapid and straightforward prediction of potential disease progression in AIDS patients with PJP at the time of initial admission may guide the early administration of glucocorticoids or antifungal medicines, such as caspofungin, in addition to the basic treatment with sulfamethoxazole-trimethoprim. This approach could significantly improve the prognosis and survival of AIDS patients with PJP.[22] Therefore, the CURB-65 score + HRCT score + WBC count may evolve into a new predictive model for assessing the probability of mortality in AIDS patients with PJP.

This study is a single-centre retrospective analysis with a relatively small sample size, and the results may have some limitations. To increase the sample size and better corroborate the findings, a multi-centre study with additional cases will be required in the future.

CONCLUSION

The CURB-65 score showed superior predictive value compared to the qSOFA score for individual indicators, and the CURB-65 score + HRCT score + WBC count provided a more accurate prediction of mortality risk than the qSOFA score + HRCT score + WBC count. From these findings, the CURB-65 score + HRCT score + WBC count may be effectively used to assess disease severity and mortality risk in AIDS patients with PJP.

ETHICAL APPROVAL:
The study was approved by the Ethics Committee of Beijing Youan Hospital, Capital Medical University, Youanmen Wai, Beijing, China (No: LL-2022-045-K).

PATIENTS' CONSENT:
Informed consent was obtained from the patients for the publication of data related to this study.

COMPETING INTEREST:
The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:
SW: Contributed to the study design, data collection, data analysis, and manuscript preparation.
YX: Contributed to the data collection.
Both authors approved the final version of the manuscript.

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