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# ORIGINAL

# PROGNOSTIC FACTORS AND CONTINUOUS MONITORING OF SERUM OXIDATIVE STRESS IN ELDERLY PATIENTS WITH SEVERE PNEUMONIA: IMPLICATIONS FOR PHYSICAL RECOVERY AND REHABILITATION STRATEGIES

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## ABSTRACT

**Objective:** To identify prognostic factors in elderly patients with severe pneumonia using multivariate logistic regression analysis and evaluate the medical value of continuous monitoring of serum oxidative stress levels, with a focus on implications for physical recovery and rehabilitation. **Methods:** A retrospective analysis was conducted on 200 elderly patients with severe pneumonia admitted to a tertiary hospital. Clinical and laboratory data, including serum oxidative stress markers (malondialdehyde [MDA] and superoxide dismutase [SOD]), were collected. Multivariate logistic regression analysis was used to identify prognostic factors for adverse outcomes, such as prolonged hospital stay, reduced functional capacity, and mortality. Oxidative stress levels were continuously monitored, and their correlation with clinical outcomes and recovery metrics was assessed. **Results:** Key prognostic factors identified included advanced age, higher C-reactive protein (CRP) levels, elevated serum MDA, reduced SOD activity, and presence of comorbidities ($P < 0.05$). Continuous monitoring of oxidative stress markers revealed significant correlations between elevated MDA levels, decreased SOD activity, and adverse outcomes such as longer hospitalization and delayed physical recovery. Patients with improved oxidative stress profiles demonstrated faster recovery and better functional outcomes, including improved mobility and reduced fatigue. **Conclusion:** Multivariate logistic regression analysis identified serum oxidative stress markers as significant prognostic factors in elderly patients with

severe pneumonia. Continuous monitoring of oxidative stress provides valuable insights for predicting recovery trajectories and optimizing rehabilitation strategies. These findings highlight the importance of integrating oxidative stress management into multidisciplinary care approaches, particularly for enhancing physical recovery and improving quality of life in elderly patients. Further research is needed to explore the role of targeted interventions, such as antioxidant therapy and tailored physical activity programs, in mitigating oxidative stress and promoting functional recovery.

**KEYWORDS:** Critical Medicine; Senile SP; Logistic Regression Analysis; Serum Oxidative Stress Level; Medical Value

## 1. INTRODUCTION

Severe pneumonia is a leading cause of morbidity and mortality among the elderly, a population particularly vulnerable due to age-related physiological changes, diminished immune function, and the presence of comorbidities. Beyond its immediate impact, severe pneumonia often leaves lasting effects on physical health, functional independence, and quality of life. Prolonged hospitalization (Cilloniz, Pericàs, & Rojas, 2022; Póvoa, Coelho, & Salluh, 2021; Qu et al., 2022)., increased inflammation, and systemic complications frequently lead to muscle weakness, reduced mobility, and an extended recovery period. Understanding the factors that influence outcomes in this population is crucial for designing effective therapeutic and rehabilitation strategies. Among the key contributors to the progression of severe pneumonia is oxidative stress, a condition characterized by an imbalance between the production of reactive oxygen species (ROS) and the body's antioxidant defenses. Excessive oxidative stress not only exacerbates inflammation but also impairs tissue repair and contributes to the development of multi-organ dysfunction. In elderly patients, where antioxidant defenses are naturally reduced, oxidative stress can become a major determinant of clinical outcomes. Serum biomarkers such as malondialdehyde (MDA), a marker of lipid peroxidation, and superoxide dismutase (SOD), a key antioxidant enzyme, provide measurable indicators of oxidative stress levels. Monitoring these markers continuously during hospitalization could offer valuable insights into disease progression and recovery potential. The use of multivariate logistic regression analysis allows for the identification of critical prognostic factors in complex clinical scenarios. This statistical approach integrates diverse data, including biochemical, clinical, and demographic variables, to create predictive models that can inform individualized patient care. For elderly patients with severe pneumonia, identifying factors associated with outcomes such as mortality, length of hospital stay, and functional recovery can guide the development of personalized treatment plans and early rehabilitation programs (Dean & Florin, 2018; Lee et al., 2021). Physical recovery is a crucial aspect of post-pneumonia care, particularly for elderly patients aiming to regain

independence and resume normal activities. However, oxidative stress can hinder this recovery by inducing muscle atrophy, reducing endurance, and impairing cardiovascular function. These effects highlight the need for a comprehensive approach to managing oxidative stress as part of the broader rehabilitation process. Antioxidant therapies, coupled with targeted physical activity programs, may play a vital role in mitigating these effects and promoting recovery (Ceccato et al., 2021; Florin et al., 2020; Haggie, Selvadurai, Gunasekera, & Fitzgerald, 2021; H. Wang et al., 2020). The integration of oxidative stress monitoring into clinical practice aligns with the growing emphasis on multidisciplinary care models in sports and rehabilitation medicine. By addressing both systemic inflammation and physical deconditioning, such approaches can enhance the effectiveness of rehabilitation interventions and improve long-term outcomes (D. Wang, Willis, & Yih, 2022).. Furthermore, the application of predictive models can help clinicians identify high-risk patients early, enabling timely interventions that prevent complications and facilitate recovery. This study aims to achieve two primary objectives: first, to identify key prognostic factors in elderly patients with severe pneumonia through multivariate logistic regression analysis, and second, to evaluate the medical value of continuous serum oxidative stress monitoring in predicting outcomes and guiding interventions. By bridging clinical research with rehabilitation-focused applications, this work seeks to contribute to the development of holistic care strategies that prioritize physical recovery, functional independence, and overall quality of life for elderly patients recovering from severe pneumonia (Gautam et al., 2020; Karakioulaki & Stolz, 2019).

## 2. Patients and Methods

### 2.1. General Information

During March 2021 to March 2022, 240 elderly patients with SP cured in our hospital were enrolled as severe group, containing 128 men and 112 women. The age of cases with SP was 68.49±10.28 years old. At the same time, 200 patients with common pneumonia treated in our hospital in the same period were enrolled as the general group, containing 110 men and 90 women. The age of cases in the general group was 69.27±9.33 years old. Sex, age, and other general characteristics did not show any significant differences (P>0.05). Patients and their families who participated in this study provided written informed consent, which was approved by the hospital's ethics committee. The patients with SP were followed up for 6 months and classified into either the good prognosis group or the poor prognosis group based on predetermined prognostic criteria. The prognostic criteria are as follows: good prognosis is defined as patient survival and recovery; poor prognosis group is defined as patients dying or surviving but with sequelae that affect quality of life. The selection criteria of severe group were as follows: (1) the cases in the severe group were in accordance with the diagnostic criteria of SP (de Mangou et al.,

2022); (2) patients aged 60 years and above; (3) patients with complete clinical data. Exclusion criteria for severe group: (1) patients with history of use of antibiotics, glucocorticoids and immunosuppressants within 3 months before admission; (2) patients with pulmonary diseases like chronic obstructive pulmonary disease and pulmonary tuberculosis; (3) patients with cardiovascular and cerebrovascular diseases, severe hepatic and renal insufficiency and blood coagulation dysfunction; (4) patients with malignant tumor disease; (5) patients who died or were discharged automatically within 24 hours after admission; (6) those with dementia and other mental disorders cannot cooperate with the development of this study. The inclusion criteria of common pneumonia: (1) the cases in the general group were in accordance with the diagnostic criteria of common pneumonia (Godoy, Dalla Pria, Truong, Shroff, & Marom, 2022), and diagnosed as common pneumonia by blood routine, chest CT and X-ray examination; (2) no complications such as heart failure. Exclusion criteria of common pneumonia: (1) long-term use of immunosuppressants; (2) there were clear immunodeficiency, malignant tumors, congenital heart disease and other basic diseases.

### 2.2. Treatment Methods

The age, sex, PSI score of complicated basic diseases, acute physiology and chronic health assessment II score, mechanical ventilation, indwelling catheter in the body, lying flat within 2 hours after meals and other data were recorded. Within 24 hours of admission, a 5mL sample of fasting venous blood was collected and then centrifuged at 3000r/min for 10 minutes. The separated serum was placed in anticoagulant vessels and stored in a constant temperature refrigerator at -70 ℃. The level of PCT was detected by fluorescence immunochromatography, and the kit was enrolled from Jiangxi Yingda Biotechnology Co., Ltd. The thiobarbital colorimetry was used to detect malondialdehyde (MDA) and xanthine oxidation method was used to detect superoxide dismutase (SOD). The kits were harvested from Nanjing Senbega Biotechnology Co., Ltd. According to the patient's condition and treatment guidelines, routine treatments such as anti-infective, expectorant, anti-asthmatic, vasoactive drugs, correcting water-electrolyte and acid-base imbalance were given, and ventilator-assisted respiratory therapy was given according to the patient's condition.

### 2.3. Observation Index

(1) The study compared the levels of oxidative stress indexes between different groups of patients; (2) Follow-up of SP patients was performed through telephone follow-ups or outpatient reexaminations until September 2022, or until death. They were then categorized into different groups based on the predetermined prognostic criteria; (3) The study analyzed the factors that were associated with the prognosis of elderly patients with SP.

### 2.4. Statistical Analysis

Statistical software SPSS22.0 was used to process the data. The measured data with normal distribution and homogeneous variance were represented by ($\overline{x}$±s). Using the independent samples T-test, the counting data was compared between groups, and chi-square analysis was used to determine the difference between groups. Multivariate logistic regression analysis was adopted to analyze the statistically remarkable indexes in univariate analysis. Monitoring oxidative stress index in elderly patients with SP with poor prognosis was assessed using the receiver operating characteristic (ROC). Statistics showed a remarkable difference (P<0.05).

## 3. Results

### 3.1. The Oxidative Stress Indexes between Severe Group and Normal Group

Compared to the normal group, the serum MDA level in the severe group was higher, and the serum SOD level was remarkably lower (P<0.05, Table 1).

**Table 1:** The Oxidative Stress Indexes between Severe Group and Normal Group（$\overline{x}$±S）

| GROUP | N | MDA（μmol/L） | SOD（U/L） |
|---|---|---|---|
| **SEVERE GROUP** | 240 | 9.64±0.83 | 50.32±4.29 |
| **GENERAL GROUP** | 200 | 3.56±2.31 | 73.49±6.62 |
| ***T*** | | 37.949 | 44.218 |
| ***P*** | | ＜0.05 | ＜0.05 |

### 3.2. The Oxidative Stress Indexes in Patients with SP with different Prognosis

Compared to the poor prognosis group, the serum MDA level in the good prognosis group was lower, and the serum SOD level was remarkably higher (P<0.05, Fig.1).

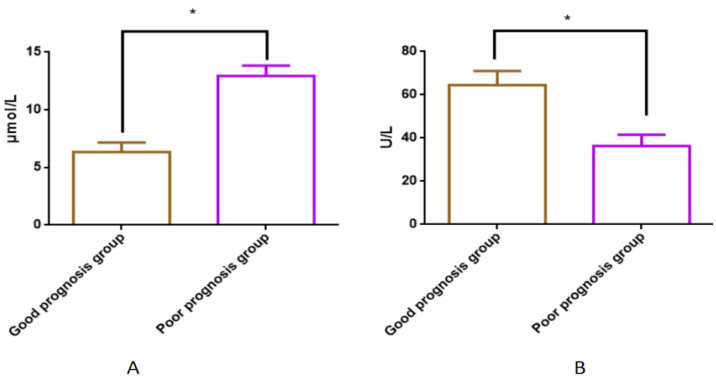


**Figure: 1:** The Oxidative Stress Indexes in Patients with SP with different Prognosis (a: serum MDA level; B: serum SOD level; *P＜0.05).

### 3.3. The Clinical Characteristics of Patients with SP with different Prognosis

The clinical characteristics of patients with good and poor prognosis were compared, containing age, mechanical ventilation, bed rest for 2 hours after a meal, indwelling catheter, PSI score, APACE II score, and abnormal PCT (P<0.05, Table 2). No remarkable difference was found in gender and underlying diseases (P>0.05).

**Table 2:** The Clinical Characteristics of Patients with SP with different Prognosis

| GROUPING | GROUP WITH GOOD PROGNOSIS （n=104） | POOR PROGNOSIS GROUP （n=136） | *t/χ2* | *P* |
|---|---|---|---|---|
| **AGE (YEARS)** | 71.56±5.23 | 78.63±6.45 | *9.118* | *<0.05* |
| **GENDER（n/%）** | | | *0.019* | *>0.05* |
| **MALE** | 56（53.85） | 72（52.94） | | |
| **FEMALE** | 48（46.15） | 64（47.06） | | |
| **CONCOMITANT UNDERLYING DISEASES（n/%）** | | | *3.081* | *>0.05* |
| **CORONARY ARTERY DISEASE** | 38（36.54） | 48（35.29） | | |
| **HIGH BLOOD PRESSURE** | 36（34.62） | 56（41.18） | | |
| **DIABETES** | 20（19.23） | 26（19.12） | | |
| **HYPERLIPIDEMIA** | 10（9.62） | 6（4.41） | | |
| **MECHANICAL VENTILATION （n/%）** | | | | |
| **YES** | 60（57.69） | 108（79.41） | *13.239* | *<0.05* |
| **NO** | 44（42.31） | 28（20.59） | | |
| **LIE FLAT 2 HOURS AFTER MEAL（n/%）** | | | *42.959* | *<0.05* |
| **YES** | 70（67.31） | 34（25.00） | | |
| **NO** | 34（32.69） | 102（75.00） | | |
| **INDWELLING CATHETER IN VIVO（n/%）** | | | *10.290* | *<0.05* |
| **YES** | 54（51.92） | 98（72.06） | | |
| **NO** | 50（48.08） | 38（27.94） | | |
| **PSI CORING（POINTS）** | 142.61±14.26 | 159.87±15.31 | *8.914* | *<0.05* |
| **APACEⅡ SCORING（POINTS）** | 16.22±5.09 | 23.84±5.63 | *10.827* | *<0.05* |
| **PCT（n/%）** | | | *149.124* | *<0.05* |
| **NORMAL** | 6（5.77） | 116（85.29） | | |
| **ABNORMAL** | 98（94.23） | 20（14.71） | | |

### 2.4. Univariate Analysis of Poor Prognosis in Elderly Patients with SP

We selected the statistically remarkable factors identified in the univariate analysis as independent variables, and used poor prognosis as the dependent variable (Yes=1 and No=0). The specific assignment table is shown in Table 3. The results indicated that age, mechanical ventilation, lying down 2 hours after meals, PSI score, APACE Ⅱ score, serum PCT level, serum MDA level and serum SOD level were all risk factors for poor prognosis of elderly patients with SP (P<0.05). All the results are shown in Table 3 and Table 4.

**Table 3:** Analysis of Factors Affecting Poor Prognosis of Elderly Patients with SP

| RELATED FACTORS | VARIABLE NAME | VARIABLE ASSIGNMENT |
|---|---|---|
| AGE | $X_1$ | > 65 years old =1，≤65 years old =0 |
| MECHANICAL VENTILATION | $X_2$ | Yes =1，No =0 |
| LIE FLAT 2 HOURS AFTER MEAL | $X_3$ | Yes =1，No =0 |
| INDWELLING CATHETER IN VIVO | $X_4$ | Yes =1，No =0 |
| PSI SCORING | $X_5$ | ＞150 分=1，≤150 分=0 |
| APACE Ⅱ SCORING | $X_6$ | ＞20 分=1，≤20 分=0 |
| PCT | $X_7$ | Abnormal =1，Normal =0 |
| SERUM MDA HORIZONTAL | $X_8$ | Actual value |
| SERUM SOD HORIZONTAL | $X_9$ | Actual value |

**Table 4(a):** Univariate Analysis of Factors Related to Poor Prognosis in Elderly Patients with SP

| VARIABLE | B | S.E. | CHI-SQUARE VALUE | *P* VALUE | OR VALUE （95%CI） |
|---|---|---|---|---|---|
| AGE | 1.323 | 0.472 | 7.857 | 0.005 | 3.755 （1.489~9.470） |
| LIE FLAT WITHIN 2 HOURS AFTER MEAL | 1.703 | 0.307 | 30.772 | 0.000 | 5..490 （3.008~10.021） |
| MECHANICAL VENTILATION | 3.015 | 0.715 | 17.781 | 0.000 | 20.389 （5.021~82.798） |
| INDWELLING CATHETER IN VIVO | 1.322 | 1.017 | 1.690 | 0.194 | 3.751 （0.511~27.531） |
| PSI SCORING | 2.324 | 1.033 | 5.061 | 0.024 | 10.216 （1.349~77.376） |
| APACE Ⅱ SCORING | 1.084 | 0.342 | 10.046 | 0.002 | 2.956 （1.512~5.780） |

**Table 4(b):** Univariate Analysis of Factors Related to Poor Prognosis in Elderly Patients with SP

| VARIABLE | B | S.E. | CHI-SQUARE VALUE | *P* VALUE | OR VALUE （95%CI） |
|---|---|---|---|---|---|
| PCT | 2.035 | 1.012 | 4.044 | 0.044 | 7.652 （1.053~55.619） |
| SERUM MDA HORIZONTAL | 1.834 | 0.394 | 21.667 | 0.000 | 6.259 （2.891~13.548） |
| SERUM SOD HORIZONTAL | 1.240 | 0.435 | 8.126 | 0.004 | 3.456 （1.473~8.106） |

### 3.5. Multiple Factors Affecting Poor Prognosis of Elderly Patients with SP

Logistic regression results indicated that age, mechanical ventilation, lying down 2 hours after meals, PSI score, APACE Ⅱ score, serum PCT level, serum MDA level and serum SOD level were all independent risk factors for poor prognosis of elderly patients with SP (P<0.05). All the results are shown in Table 5.

**Table 5:** Logistic Regression Analysis of Multiple Factors Related to Poor Prognosis in Elderly Patients with SP

| VARIABLE | B | S.E. | CHI-SQUARE VALUE | *P VALUE* | OR（95%CI） |
|---|---|---|---|---|---|
| AGE | 0.724 | 0.304 | 5.672 | 0.017 | 2.063（1.137-3.743） |
| LIE FLAT WITHIN 2 HOURS AFTER MEAL | 1.109 | 0.333 | 11.091 | 0.001 | 3.031（1.578-5.822） |
| MECHANICAL VENTILATION | 0.769 | 0.292 | 6.936 | 0.008 | 2.158（1.217-3.824） |
| PSI SCORING | 0.682 | 0.214 | 10.156 | 0.001 | 1.978（1.300-3.008） |
| APACE Ⅱ SCORING | 0.635 | 0.222 | 8.182 | 0.004 | 1.887（1.221-2.916） |
| PCT | 1.204 | 0.872 | 1.906 | 0.167 | 3.333 （ 0.603-18.414） |
| SERUM MDA HORIZONTAL | 1.008 | 0.352 | 8.200 | 0.004 | 2.740（1.374-5.463） |
| SERUM SOD HORIZONTAL | 0.984 | 0.325 | 9.167 | 0.002 | 2.675（1.415-5.058） |

### 3.6. Diagnostic Value of Monitoring the Level of Oxidative Stress Index in the Poor Prognosis of Elderly Patients with SP

To analyze the predictive effect of continuous monitoring of oxidative

stress index level on the poor prognosis of elderly patients with SP, the ROC curve was utilized. According to the results, the AUC of serum MDA level in predicting poor prognosis of elderly patients with SP was 0.747 (95%CI: 0.6396-0.8542), with a sensitivity of 65.39% and a specificity of 75.82%. The AUC of serum SOD level in predicting poor prognosis of elderly patients with SP was 0.819 (95% CI: 0.7302-0.9083), with a sensitivity of 77.42% and a specificity of 85.83%. All the results are shown in Fig. 2 and Fig. 3.

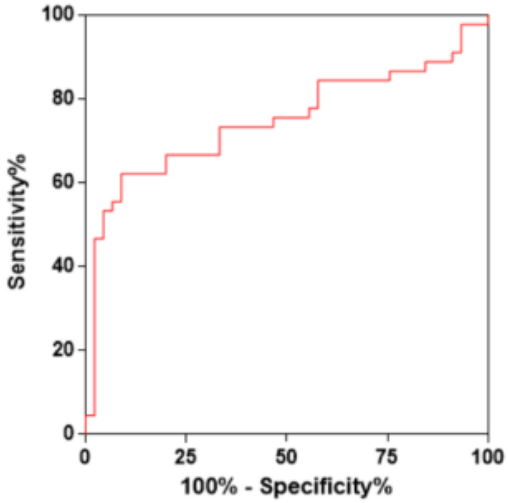


**Figure. 2:** ROC Curve of Serum MDA Level Predicting Poor Prognosis in Patients with SP

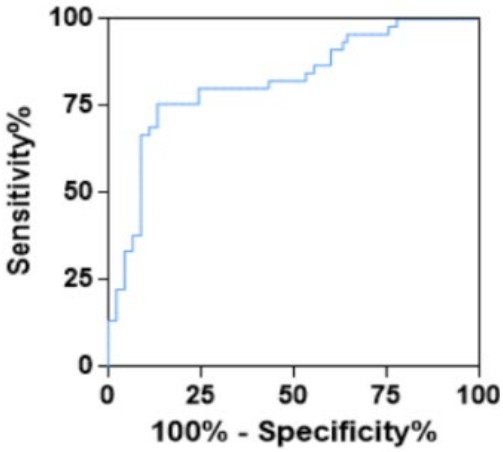


**Figure. 3:** ROC Curve of Serum SOD Level Predicting Poor Prognosis in Patients with SP

## 4. Discussion

Severe pneumonia (SP) is characterized by a high incidence, rapid progression, difficulty in treatment, and high mortality rate (Kaneta et al., 2022). It has been reported that the mortality rate of SP in China can reach 20%~50% every year (Losonczy, Lukácsovits, Süttő, Lorx, & Müller, 2021; J. Wang & Song, 2019; R. Zhang, Wang, Tian, & Deng, 2021). Thus, it is crucial to enhance the analysis of factors related to the prognosis of elderly patients with SP. After

performing multivariate logistic regression analysis on the clinical data of 240 elderly patients with SP in our hospital, it was discovered that age, mechanical ventilation, lying down 2 hours after meals, PSI score, APACHE II score, and serum levels of PCT, MDA, and SOD were the primary risk factors. The results are roughly the same as those of previous studies. Due to the combination of various underlying diseases such as diabetes and hypertension, as well as the decline in body functions and immunity, elderly people are prone to develop SP after being infected by pathogens. The PSI score is a scoring system that reflects the severity of pneumonia and can be combined with the patient's underlying illness. It consists of 3 items of demographic information, 5 items of underlying disease, 5 items of physical examination and 7 items of laboratory tests. PSI score can not only evaluate the severity of pneumonia, but also directly evaluate the basic diseases. APACHE II score is the most widely used critically ill assessment system, containing acute physiological score, age score and chronic health score. The evaluation of APACHE II score is standard quantitative method, which can accurately evaluate the condition and prognosis of critically ill patients. A higher score indicates a worse prognosis. Consequently, these two scoring systems can be utilized as one of the primary risk factors that affect the prognosis of elderly patients with SP. According to previous reports, mechanical ventilation is considered an independent risk factor for mortality in patients with SP (Fan et al., 2022; Mala et al., 2022). While the treatment, some elderly patients require mechanical ventilation to extend their lives, as well as various invasive procedures and therapies, which, combined with the excessive use of antibiotics during treatment, leads to a remarkable increase in mortality. Patients who require mechanical ventilation are often in a critical condition, and therefore, this factor is considered a significant risk factor for the prognosis of patients (Chowdhury et al., 2022). In addition, it is also critical for patients to choose which position to rest after eating. It has been suggested that patients in a supine position within 2 hours of eating are prone to aspiration pneumonia and that maintaining a sitting position is an effective measure to prevent aspiration pneumonia (Wu, Gu, Cai, Zhai, & Zhan, 2021). Elderly patients are susceptible to gastro-esophageal reflux after eating as their body organs gradually deteriorate and the esophageal sphincter becomes flaccid (Chang et al., 2022). In addition, the swallowing and coughing reflexes of elderly patients can be remarkably reduced, making it easier to cause regurgitation in the stomach and accidental aspiration into the airways, which can aggravate lung infections (Kang et al., 2021). Therefore, more attention should be paid to the daily nursing of patients in clinic, and the sitting position should be enrolled as far as possible within 2 hours after eating. SP is an inflammation of pulmonary parenchyma caused by bacteria, viruses, or other atypical pathogens (Tsai et al., 2022). Clinical diagnosis of pneumonia is often combined with imaging findings, while seeking effective indicators to correctly judge the condition and evaluate the prognosis of patients. It can provide effective evidence for treatment and is the focus of clinical researchers (Kose

et al., 2020; Rachina et al., 2021). There are many clinical indicators used to detect infection, containing etiological examination, cytokine levels and hemogram, but they all have the disadvantages of long examination time and low specificity. As the calcitonin gene-related peptide, PCT can be synthesized and released upon stimulation by bacterial toxins and cytokines and is highly specific and sensitive for the differential diagnosis of infections (Wussler et al., 2019). Consistent with previous studies, the levels of PCT were found to be significantly higher in patients with poor prognosis compared to those with good prognosis in this study (Kamat, Ramachandran, Eswaran, Guffey, & Musher, 2020). This suggests that the detection of PCT levels in elderly patients with SP is a valuable tool for evaluating their prognosis. It is found that the inflammatory state of SP can lead to the imbalance of oxidative stress system, the production of many reactive oxygen species and the increase of peroxidation products such as MDA. With the aggravation of oxidative stress, antioxidant substances are continuously consumed and the content decreases (Q. Zhang, Ju, Ma, & Wang, 2018). This shows that oxidative stress is involved in the pathological process of SP to a certain extent. This study's results demonstrated that the serum levels of MDA and SOD in patients with SP were significantly distinct from those in patients with normal pneumonia, suggesting that patients with SP have substantially higher levels of oxidative stress compared to patients with normal pneumonia. This result suggests that the changes in the levels of oxidative stress indicators are closely associated with the onset and progression of SP. In our study, a comparison was made between the levels of oxidative stress indicators among patients with good prognosis and those with poor prognosis. The results showed that patients with good prognosis had lower serum MDA levels and higher serum SOD levels as compared to those with poor prognosis. It is suggested that the levels of serum MDA and SOD may be used as reference indexes to predict the poor prognosis of patients with SP. The findings led to the performance of ROC curve analysis to assess the predictive ability of serum MDA and SOD levels in anticipating poor prognosis in patients with SP. The predictive performance of serum MDA levels for poor prognosis in elderly patients with SP was indicated by an AUC of 0.747, while the AUC of serum SOD levels for predicting poor prognosis of elderly patients with SP was 0.819. The above data suggest that monitoring serum MDA and SOD levels in patients with SP can better predict the risk of poor prognosis and lead to the formulation of timely and scientific prevention and treatment measures to improve the prognosis of patients, with serum SOD levels being of higher predictive value.

## 5. Conclusion

This study highlights the critical role of oxidative stress and its prognostic significance in elderly patients with severe pneumonia. By utilizing multivariate logistic regression analysis, key factors such as serum oxidative stress markers (MDA and SOD), age, inflammatory markers, and comorbidities were identified

as significant predictors of clinical outcomes. Continuous monitoring of oxidative stress not only provides valuable insights into the disease trajectory but also offers an opportunity to tailor interventions for improved recovery. The findings underscore the importance of addressing oxidative stress as part of a comprehensive treatment and rehabilitation strategy. Elevated oxidative stress levels were associated with prolonged hospitalization, reduced physical recovery, and poorer overall outcomes. Conversely, patients with improved oxidative profiles demonstrated faster recovery, better functional capacity, and a greater ability to participate in rehabilitation programs, emphasizing the relevance of oxidative stress management in promoting physical resilience. Integrating oxidative stress monitoring into clinical practice has significant implications for rehabilitation and sports medicine. Targeted interventions, including antioxidant therapies, dietary modifications, and personalized physical activity programs, can mitigate the impact of oxidative stress, enhance physical recovery, and improve long-term functional outcomes. These approaches are particularly important for elderly patients, where the interplay between inflammation, oxidative stress, and physical deconditioning poses unique challenges. Future research should focus on validating these findings in larger cohorts and exploring the efficacy of combined therapeutic strategies, such as antioxidants and structured exercise programs, in managing oxidative stress and improving recovery trajectories. Additionally, investigating the role of oxidative stress in other populations, including athletes and physically active individuals recovering from severe illnesses, could expand the applicability of these findings. In conclusion, this study provides a foundation for integrating oxidative stress monitoring and management into multidisciplinary care frameworks. By addressing both systemic health and physical recovery, healthcare providers can better support elderly patients in achieving optimal outcomes and enhancing their quality of life during and after recovery from severe pneumonia.

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