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ORIGINAL RESEARCH

Evaluating dysfunction of diaphragm and weakness due to ICU stay in septic shock patients with or without mechanical ventilation: a clinical study

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Abstract

Background:

Septic shock is a critical condition often leading to respiratory failure, necessitating mechanical ventilation in intensive care unit (ICU) patients. Diaphragm dysfunction and ICU-acquired weakness are common complications in such patients, but their prevalence and association with mechanical ventilation in the context of septic shock remain unclear. This pilot prospective observational study aimed to investigate diaphragm dysfunction and ICU-acquired weakness in septic shock patients with or without mechanical ventilation.

Materials and Methods:

We conducted this study at a tertiary hospital over a period from October 2022 to March 2023. A total of 45 septic shock patients were included in the study. Demographic and clinical data were collected, including the need for mechanical ventilation, duration of mechanical ventilation, and the presence of diaphragm dysfunction and ICU-acquired weakness. Diaphragm dysfunction was assessed using ultrasound, while ICU-acquired weakness was evaluated using clinical criteria and standardized assessments.

Results:

Of the 45 septic shock patients included in the study, 25 (55.6%) required mechanical ventilation. Among mechanically ventilated patients, the average duration of mechanical ventilation was 8.5 ± 3.2 days. Diaphragm dysfunction was observed in 60% of mechanically ventilated patients compared to 20% of non-ventilated patients. ICU-acquired weakness was present in 48% of mechanically ventilated patients and 15% of non-ventilated patients. The

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difference in the prevalence of both diaphragm dysfunction and ICU-acquired weakness between the two groups was statistically significant ($p < 0.05$).

Conclusion:

This pilot study suggests a high prevalence of diaphragm dysfunction and ICU-acquired weakness in septic shock patients, with a significantly greater occurrence in those requiring mechanical ventilation. These findings highlight the importance of monitoring and managing diaphragm function and muscle weakness in septic shock patients, especially those on mechanical ventilation, to potentially improve outcomes in this vulnerable population.

Keywords:

Septic shock, diaphragm dysfunction, ICU-acquired weakness, mechanical ventilation, observational study, critical care, intensive care unit.

Introduction

Septic shock is a life-threatening condition characterized by a dysregulated host response to infection, leading to profound circulatory and metabolic disturbances (1). It is a major cause of morbidity and mortality in intensive care units (ICUs) worldwide (2). Septic shock often necessitates mechanical ventilation to support respiratory function and ensure adequate oxygenation and ventilation (3). However, prolonged mechanical ventilation can lead to various complications, including diaphragm dysfunction and ICU-acquired weakness (4,5).

Diaphragm dysfunction refers to impaired diaphragmatic contractility, which can result in ventilatory inefficiency and difficulties in weaning patients off mechanical ventilation (6). ICU-acquired weakness, on the other hand, involves generalized muscle weakness that affects limb and respiratory muscles, further complicating the clinical course of critically ill patients (7). These complications not only prolong the duration of mechanical ventilation but also increase the risk of complications and mortality (8).

While the prevalence of diaphragm dysfunction and ICU-acquired weakness has been well-documented in the ICU setting, their specific association with septic shock and mechanical ventilation remains less clear (9,10). Understanding the prevalence and relationship of these complications in septic shock patients is essential for improving patient care and outcomes.

This pilot prospective observational study aims to investigate diaphragm dysfunction and ICU-acquired weakness in septic shock patients, both those who require mechanical ventilation and those who do not. By exploring these aspects, we hope to contribute to a better understanding of the clinical implications and potential management strategies for these common complications in the context of septic shock.

Materials and Methods:

Study Design and Setting:

This prospective observational study was conducted at a tertiary hospital between October 2022 and March 2023. The study aimed to assess diaphragm dysfunction and ICU-acquired weakness in septic shock patients, comparing those who required mechanical ventilation with those who did not.

Study Participants:

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

A total of 45 septic shock patients were enrolled in the study. Inclusion criteria included a diagnosis of septic shock according to the Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3) criteria (1). Patients aged 18 years and older were eligible for inclusion. Exclusion criteria consisted of preexisting neuromuscular diseases and conditions that could confound the assessment of diaphragm function and muscle weakness.

Data Collection:

Demographic and clinical data were collected for each participant, including age, gender, comorbidities, and Acute Physiology and Chronic Health Evaluation (APACHE) II scores to assess disease severity. The primary outcome measures were the presence of diaphragm dysfunction and ICU-acquired weakness.

Assessment of Diaphragm Dysfunction:

Diaphragm dysfunction was assessed using ultrasound. Diaphragm thickness and excursion were measured by trained sonographers during end-expiration and end-inspiration, respectively. Diaphragm dysfunction was defined as a decrease in diaphragm excursion or thickness during inspiration compared to expiration.

Assessment of ICU-Acquired Weakness:

ICU-acquired weakness was evaluated using clinical criteria and standardized assessments, including the Medical Research Council (MRC) scale and handgrip dynamometry. Patients with an MRC score of less than 48/60 were considered to have ICU-acquired weakness.

Statistical Analysis:

Descriptive statistics were used to summarize patient characteristics and outcomes. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as means ± standard deviations (SD) or medians with interquartile ranges (IQR), as appropriate. Comparisons between mechanically ventilated and non-ventilated groups were performed using Chi-squared tests for categorical variables and t-tests or Mann-Whitney U tests for continuous variables, depending on data distribution. A p-value of less than 0.05 was considered statistically significant.

Results:

A total of 45 septic shock patients were included in this study, with 25 (55.6%) requiring mechanical ventilation. The demographic and clinical characteristics of the study participants are summarized in Table 1.

Table 1: Demographic and Clinical Characteristics of Study Participants

Characteristic	**Mechanical Ventilation (n=25)**	**No Mechanical Ventilation (n=20)**
Age (years), mean ± SD	62.4 ± 8.7	59.1 ± 7.5
Gender (Male), n (%)	16 (64.0%)	12 (60.0%)
APACHE II Score, mean ± SD	28.2 ± 4.1	25.8 ± 3.9
Comorbidities, n (%)		
- Hypertension	10 (40.0%)	8 (40.0%)

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- Diabetes Mellitus	6 (24.0%)	5 (25.0%)
- COPD	3 (12.0%)	2 (10.0%)

The average age of patients in the mechanically ventilated group was 62.4 years, while in the non-ventilated group, it was 59.1 years. The majority of patients in both groups were male, with 64.0% in the mechanical ventilation group and 60.0% in the non-ventilated group. The mean APACHE II score was higher in the mechanically ventilated group (28.2 ± 4.1) compared to the non-ventilated group (25.8 ± 3.9). The most common co morbidities in both groups were hypertension and diabetes mellitus.

Diaphragm Dysfunction:

Diaphragm dysfunction was assessed using ultrasound, and the results are presented in Table 2.

Table 2: Prevalence of Diaphragm Dysfunction

Variable	**Mechanical Ventilation (n=25)**	**No Mechanical Ventilation (n=20)**
Diaphragm Dysfunction, n (%)	15 (60.0%)	4 (20.0%)

Diaphragm dysfunction was observed in 60.0% of patients in the mechanical ventilation group, while only 20.0% of patients in the non-ventilated group had diaphragm dysfunction. The difference in the prevalence of diaphragm dysfunction between the two groups was statistically significant ($p < 0.05$).

ICU-Acquired Weakness:

The presence of ICU-acquired weakness was assessed using clinical criteria and standardized assessments, and the results are shown in Table 3.

Table 3: Prevalence of ICU-Acquired Weakness

Variable	**Mechanical Ventilation (n=25)**	**No Mechanical Ventilation (n=20)**
ICU-Acquired Weakness, n (%)	12 (48.0%)	3 (15.0%)

ICU-acquired weakness was identified in 48.0% of mechanically ventilated patients, while only 15.0% of non-ventilated patients had ICU-acquired weakness. The difference in the prevalence of ICU-acquired weakness between the two groups was statistically significant ($p < 0.05$).

These findings highlight a significantly higher prevalence of both diaphragm dysfunction and ICU-acquired weakness in septic shock patients who required mechanical ventilation compared to those who did not.

Discussion:

Septic shock is a life-threatening condition associated with significant morbidity and mortality, often necessitating intensive care management, including mechanical ventilation (1). In this pilot prospective observational study, we sought to investigate the prevalence of

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diaphragm dysfunction and ICU-acquired weakness in septic shock patients, with a specific focus on their association with mechanical ventilation. The results of this study reveal several important findings that warrant discussion.

Diaphragm Dysfunction and Septic Shock:

Our study demonstrated a substantial prevalence of diaphragm dysfunction in septic shock patients, with 60.0% of those requiring mechanical ventilation exhibiting this complication. This observation aligns with previous studies that have reported diaphragm dysfunction as a common occurrence in critically ill patients, particularly those with sepsis (2,3). The diaphragm is a crucial respiratory muscle, and dysfunction can lead to prolonged mechanical ventilation and increased mortality (4). The mechanisms contributing to diaphragm dysfunction in septic shock may include systemic inflammation, oxidative stress, and disuse atrophy (5).

Mechanical Ventilation and Diaphragm Dysfunction:

Our study further highlights a significant association between mechanical ventilation and the presence of diaphragm dysfunction in septic shock patients. Patients who required mechanical ventilation were four times more likely to develop diaphragm dysfunction compared to those who did not. Prolonged mechanical ventilation has been recognized as a risk factor for diaphragmatic atrophy and weakness (6). The use of controlled mechanical ventilation with sedation and neuromuscular blocking agents can contribute to diaphragm inactivity and dysfunction (7). Clinicians should be aware of the increased risk of diaphragm dysfunction in mechanically ventilated septic shock patients and consider strategies to mitigate this complication, such as early mobility and ventilator liberation protocols (8).

ICU-Acquired Weakness and Septic Shock:

In addition to diaphragm dysfunction, our study also revealed a high prevalence of ICU-acquired weakness in septic shock patients, particularly in those receiving mechanical ventilation. ICU-acquired weakness is a complex syndrome involving generalized muscle weakness, and it can result from various factors, including sepsis, inflammation, and immobility (9). The presence of ICU-acquired weakness in critically ill patients is associated with prolonged ICU stays, increased healthcare costs, and impaired long-term functional outcomes (10).

Mechanical Ventilation and ICU-Acquired Weakness:

Our findings suggest a strong association between mechanical ventilation and the development of ICU-acquired weakness in septic shock patients. Patients on mechanical ventilation were three times more likely to experience ICU-acquired weakness compared to those who were not ventilated. The underlying mechanisms contributing to ICU-acquired weakness in mechanically ventilated patients are multifactosrial and may involve disuse atrophy, inflammation-mediated muscle damage, and the use of neuromuscular blocking agents (11). Preventive strategies, such as early physical therapy and minimizing the use of sedatives and neuromuscular blocking agents, should be considered to mitigate ICU-acquired weakness in these patients (12).

Clinical Implications:

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

The implications of our study are significant, as diaphragm dysfunction and ICU-acquired weakness are associated with adverse outcomes in critically ill patients. Identifying these complications early and implementing interventions to preserve respiratory muscle function and overall muscle strength may improve patient outcomes. Clinicians should consider regular monitoring of diaphragm function and muscle strength in septic shock patients, especially those receiving mechanical ventilation.

Limitations:

This study has several limitations, including its small sample size and the single-center design. Additionally, the observational nature of the study precludes the establishment of causality. Further research with larger cohorts and prospective interventional studies is needed to confirm our findings and explore potential preventive strategies.

Conclusion

In conclusion, our pilot study highlights the high prevalence of diaphragm dysfunction and ICU-acquired weakness in septic shock patients, with a significant association with mechanical ventilation. These complications have the potential to impact patient outcomes and should be carefully monitored and managed in the critical care setting.

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ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

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