Research Article ISSN 2639-846X

Anesthesia & Pain Research

APACHE V Scale for Assessing the Severity of the Condition of Patients with Acute Respiratory Distress Syndrome

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Received: 28 Mar 2026; **Accepted:** 04 May 2026; **Published:** 15 May 2026

Citation: Hasanov FC, Kazimov IL, Guliyev KA, et al. APACHE V Scale for Assessing the Severity of the Condition of Patients with Acute Respiratory Distress Syndrome. Anesth Pain Res. 2026; 10(1): 1-5.

ABSTRACT

Background: *Assessment of disease severity in patients with acute respiratory distress syndrome (ARDS) admitted to the intensive care unit is crucial for selecting appropriate treatment strategies and predicting clinical outcomes. Although the APACHE II scoring system is widely used, it does not adequately reflect key ARDS-specific parameters such as hypoxemia and the degree of lung injury.*

Methods: *This study included 89 patients with confirmed ARDS treated in the intensive care unit between 2021 and 2023. Clinical, laboratory and instrumental data were analyzed, including oxygenation index (PaO_2/FiO_2), lung injury index (LII), inflammatory markers (CRP, procalcitonin, IL-6), and vital parameters. Based on the limitations of APACHE II, a modified scoring system-APACHE V-was developed by excluding less informative parameters and incorporating more relevant indicators of respiratory failure and systemic inflammation.*

Results: *The proposed APACHE V scale, consisting of 16 parameters, demonstrated improved sensitivity in assessing the severity of ARDS compared to conventional methods. Parameters such as oxygenation index and lung injury index provided a more objective evaluation of respiratory dysfunction, while inflammatory markers, particularly procalcitonin and CRP, reflected the intensity of the systemic inflammatory response. Dynamic monitoring of these indicators showed significant differences between patient groups over time.*

Conclusion: *The APACHE V scoring system offers a more comprehensive and clinically relevant tool for assessing disease severity in ARDS patients. Its use may improve the accuracy of prognosis, optimize treatment strategies, and enhance clinical decision-making in intensive care practice.*

Keywords

Acute Respiratory Distress Syndrome, a severity of disease classification system, scoring systems in intensive care unit (ICU), lung injury.

Introduction

Acute respiratory distress syndrome (ARDS) represents a severe inflammatory condition resulting from injury to the alveolar epithelium and pulmonary capillary endothelium due to various etiological factors, leading to life-threatening respiratory failure and hypoxemia [1-4]. This syndrome is characterized by diffuse alveolar damage, disruption of the alveolar-capillary membrane and inflammatory pulmonary edema [3,5].

Despite the diversity of underlying causes the mechanisms of injury and pathophysiological processes in ARDS are largely similar across different clinical scenarios [2,6-9]. Assessment of disease severity in patients admitted to the intensive care unit with

ARDS is critically important for determining optimal therapeutic strategies and predicting outcomes [1,10-12]. In modern intensive care practice various scoring systems are used to evaluate the severity of a patient's condition. These scales provide an estimation of disease severity, risk of mortality prognosis and overall clinical course [13-16].

Although numerous integrated scoring systems have been developed and widely implemented in recent decades the issue of accurate severity assessment remains relevant. This is largely due to inherent limitations of existing scales. Most of these systems rely on generalized indicators where individual clinical parameters are assigned scores that are subsequently summed to produce a final value.

However, such approaches often deficiently reflect the specific clinical features of ARDS itself. In particular insufficient attention is given to key disease-specific clinical manifestations laboratory and instrumental findings, as well as the nature and severity of complications [18,19].

Purpose

The aim of this study was to develop an improved scoring system for assessing the severity of ARDS by assigning weighted scores to key factors, including those contributing to respiratory failure, the dynamics of anatomical and physiological alterations in the lungs and major clinical manifestations observed during the disease course.

Materials and Methods

The study was conducted based on clinical data from 89 patients with a confirmed diagnosis of ARDS who were treated in the intensive care unit between 2021 and 2023. All patients underwent comprehensive clinical, instrumental and radiological evaluation, including chest X-ray and computed tomography (CT). Of the total cohort 51 patients were male (57.3%) and 38 were female (42.7%). Seventeen patients (19.1%) were younger than 50 years, while 72 patients (80.9%) were aged 50 years and older.

All patients underwent standard laboratory investigations, including complete blood count, biochemical blood analysis and coagulation profile. Instrumental assessments included chest X-ray, CT and magnetic resonance imaging (MRI) when clinically indicated. Additionally arterial blood gas analysis and acid–base balance were evaluated. Inflammatory markers, including C-reactive protein (CRP), procalcitonin and pro-inflammatory cytokines (interleukin-6) were measured.

Continuous monitoring of vital parameters was performed throughout the study period. The oxygenation index (OI) and lung injury index (LII) were calculated for each patient. The dynamics of all clinical and laboratory parameters were assessed comparatively on days I, III, V and VII.

Patients were further stratified into subgroups based on pre-existing comorbidities identified prior to the onset of ARDS. Recovery and mortality rates were compared across these subgroups. Statistical analysis included Spearman correlation analysis and the chi-square (χ^2) test to evaluate associations between variables.

Results and Discussion

In 1981 William A. Knaus and co-authors introduced a specialized scoring system for assessing the severity of critically ill patients, known as the APACHE I [1,10,20,21]. This system was designed to evaluate the condition of patients admitted to intensive care units based on the cumulative scoring of physiological and laboratory parameters.

Initially the APACHE I system included 34 physiological variables [1,10]. However, due to the complexity and limited practicality associated with such a large number of parameters, the system was subsequently simplified. The number of variables was reduced to 12, leading to the development of the APACHE II scoring system.

In 1989 the same authors proposed a more advanced version, APACHE III, which incorporated additional parameters such as serum albumin, bilirubin, glucose levels, hourly and daily urine output, and arterial carbon dioxide pressure - $PaCO_2$ [12]. Furthermore patient age and the presence of chronic diseases were also included in the assessment model.

Despite further development, including the introduction of APACHE IV, these later versions did not achieve widespread adoption in routine intensive care practice, primarily due to their complexity and the extensive number of variables required.

Currently, the APACHE II scale remains widely accepted as a "gold standard" for assessing disease severity in intensive care units across Europe and many other parts of the world. According to this system, each physiological parameter that deviates from normal values within the first 24 hours of ICU admission is assigned a score ranging from 0 to 4 points. In addition patient age, comorbidities, and surgical status are incorporated into the final evaluation.

The total APACHE II score ranges from 0 to 71 points, with higher scores indicating greater severity of illness and an increased risk of mortality.

Despite the widespread acceptance of the APACHE II scale in many leading clinics, it does not adequately reflect key parameters specific to acute respiratory failure and ARDS, particularly the degree of hypoxemia and the extent of lung injury. These factors, however, play a central role in determining disease severity and clinical outcomes in such patients.

Taking these limitations into account, we developed a modified and improved scoring system APACHE V - specifically designed for patients in whom respiratory failure and ARDS are the primary determinants of clinical severity. The characteristics of the APACHE V scale are presented in Table 1.

In the proposed APACHE V scale, age-related scoring is incorporated as follows: patients younger than 45 years receive 0 points; 45–54 years – 2 points; 55–64 years – 3 points; 65–75 years – 5 points; and older than 75 years – 6 points. To improve clinical relevance, several less informative parameters from the APACHE II system were excluded and replaced with indicators more directly reflecting the severity of respiratory dysfunction and systemic inflammation. These include the Oxygenation Index - OI, Lung Injury Index - LII [17], daily urine output as a marker of renal function and key inflammatory markers such as C-reactive protein, procalcitonin and interleukin-6 (IL-6).

Thus, the proposed APACHE V scale consists of 16 parameters that more comprehensively capture the severity of ARDS and respiratory failure. Particular importance is attributed to the dynamic changes in inflammatory markers, especially CRP and procalcitonin, which reflect the intensity of the systemic inflammatory response underlying ARDS. Procalcitonin, a complex glycoprotein, is recognized for its high sensitivity and specificity in assessing the severity of systemic inflammation and is therefore considered a priority biomarker in this context.

In contrast to APACHE II, where oxygenation assessment depends on the fraction of inspired oxygen (FiO_2) and utilizes either the alveolar–arterial oxygen gradient or arterial oxygen pressure (PaO_2), the proposed scale prioritizes more direct and clinically informative indices. Specifically, the use of the Oxygenation Index (PaO_2/FiO_2) and Lung Injury Index provides a more objective evaluation of gas exchange impairment and lung damage in ARDS patients.

The formulas used for calculation are as follows:

- **Oxygenation Index (OI):** PaO_2 / FiO_2
- **Lung Injury Index (LII):** $(FiO_2 \times Ppeak / PaO_2) \times 10$

Where: peak represents the peak inspiratory airway pressure and FiO_2 is the fraction of inspired oxygen.

For example, under normal conditions: LII = (0.21 × 15 / 90) × 10 = 0.35

Table 1: APACHE V scale for assessing the severity of ARDS patients (additional parameters: Oxygenation Index, Lung Injury Index, CRP, procalcitonin).

Parameters	Scores								
	4	3	2	1	0	1	2	3	4
Rectal T (°C)	>41.0	39.0-40.9		38.5-38.9	36.0-38.4	34.0-35.9	32.0-33.9	30.0-31.9	<29.9
Mean Arterial Pressure (mm Hg)	>160	130-159	110-129		70-109		50-69		<49
Heart rate (1 min.)	>180	140-179	110-139		70-109		55-69	40-54	<39
Respiratory rate (1 min.)	>50	35-49		25-34	12-24	10-11	6-9		<5
Oxygenation index	<100	100-200	200-250	250-300	>300				
Lung Injury Index	≥7	5-7	3-5	1-3	<1				
Arterial pH	>7.70	7.60-7.59		7.50-7.59	7.33-7.49		7.25-7.32	7.15-7.24	<7.15
Na+ (mmol/l)	> 180	160-179	155-159	150-154	130-149		120-129	119	<110
K+ (mmol/l)	>7.0	6.0-6.9		5.5-5.9	3.5-5.4	3.0-3.4	2.5-2.9		<2.5
Creatine(mol/l)	>300	171 -299		121 -170	50-120		<50		
Hb g|dl	>16	15-16		<11	>11	9.1-11	8.1-9	6-8	<6
Ht (%)	>60		50-59.9	46-49.9	30-45.9		20-29.9		<20
Leukocytes ($\times 10^9/l$)	>40		20-39.9	15-19.9	3-14.9		1-2.9		<1
Urine ml/h	10<	20-30	30-40	40-50	>50				
CRP mg/l	>100	>5	3-5	1-3	<1				
Procalcitonin mcg/l	>20	10 – 20	>2	>0.5	<0.5				

Table 2: Dynamic indicators of lung injury index.

Lung Injury Index		Number of patients (n)	Mean	Std dev	Std error	95% Confidence Interval for Mean		Min	max	P
						Lower bound	Upper bound			
I day	Control	63	5.05	1.02	0.13	4.79	5.30	3.6	8.118	0.002
	Main	26	4.40	0.38	0.07	4.25	4.55	3.714	5.169	
	Total	89	4.86	0.93	0.10	4.66	5.05	3.6	8.118	
III day	Control	62	4.63	1.04	0.13	4.37	4.90	3.263	7.125	0.001
	Main	26	3.53	0.59	0.12	3.29	3.77	2.521	4.819	
	Total	88	4.31	1.06	0.11	4.08	4.53	2.521	7.125	
V day	Control	59	4.22	1.15	0.15	3.92	4.52	2.778	6.645	0.001
	Main	26	2.95	0.86	0.17	2.60	3.30	1.944	4.452	
	Total	85	3.83	1.22	0.13	3.57	4.09	1.944	6.645	
VII day	Control	53	3.82	1.27	0.17	3.47	4.17	2.333	6.861	0.001
	Main	26	2.75	1.01	0.20	2.34	3.16	1.765	4.533	
	Total	79	3.47	1.29	0.14	3.18	3.75	1.765	6.861	

In pathological conditions: LII = (0.85 × 35 / 50) × 10 = 5.95

These indices allow for a more accurate and dynamic assessment of respiratory dysfunction, making the APACHE V scale potentially more sensitive and specific for evaluating disease severity in ARDS patients (Table 2).

In general, considering that a critical condition affects the organism as a whole, the functional state of individual organs and systems should be comprehensively evaluated and the severity of the patient's condition should be determined based on the cumulative score of integrated parameters.

It is well established that the primary function of vital life-support systems is adequate oxygen delivery to tissues and cells. For this purpose, the coordinated function of the respiratory, cardiovascular, and hematopoietic systems is essential.

The key indicators reflecting this functional integrity include arterial blood pressure, heart rate, respiratory rate, and hemoglobin concentration. These parameters are easily measurable and serve as sensitive markers of homeostatic imbalance, often demonstrating early changes in response to clinical deterioration.

Thus, the severity of a patient's condition can be assessed based on the degree of compensation of these physiological parameters, which reflects the capacity of vital organs to maintain adequate tissue oxygenation. In this context, the level of optimal oxygen delivery serves as a fundamental criterion for evaluating the overall clinical status of critically ill patients [18,19].

Conclusion

The results of this study demonstrate that existing scoring systems, particularly the APACHE II scale, do not fully reflect disease-specific parameters critical for assessing severity in patients with ARDS, especially hypoxemia and the degree of lung injury.

The proposed APACHE V scoring system incorporates key indicators directly related to respiratory dysfunction and systemic inflammation, including the Oxygenation Index, Lung Injury Index, and inflammatory biomarkers such as CRP, procalcitonin, and IL-6. This approach allows for a more comprehensive and pathophysiologically grounded assessment of disease severity.

Dynamic monitoring of these parameters, along with evaluation of vital functions and organ system compensation, provides a more accurate reflection of the patient's clinical condition. The findings suggest that APACHE V demonstrates improved sensitivity in detecting changes in disease severity compared to conventional scoring systems.

Therefore, the proposed scale may serve as a more informative and clinically relevant tool for assessing severity, guiding treatment strategies and predicting outcomes in patients with ARDS.

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