ORIGINAL RESEARCH PAPER
Volume - 15 | Issue - 08 | August - 2026 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

A CROSS SECTIONAL STUDY TO DETERMINE ETIOLOGICAL PROFILE OF ACUTE RESPIRATORY DISTRESS SYNDROME IN PATIENTS ADMITTED TO ICU AT SMS HOSPITAL, JAIPUR

General Medicine

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ABSTRACT

Background: Acute respiratory distress syndrome (ARDS) remains a leading cause of critical illness mortality worldwide. The precipitating causes of ARDS in India are expected to differ from those reported in high-income settings because of the burden of tropical infection, delayed presentation and constrained diagnostic capacity. Contemporary etiological data from Northwest India are scarce. **Methods:** We conducted a hospital-based, observational cross-sectional study in the medical intensive care unit (ICU) of SMS Hospital, Jaipur, between October 2023 and December 2024. Consecutive adults (≥18 years) meeting the Berlin definition of ARDS were enrolled until the calculated sample size of 120 was reached. Demographic details, precipitating cause, microbiological findings, physiological variables, biomarkers and severity scores were recorded on a structured proforma. Severity was graded by the PaO_2/FiO_2 ratio. Continuous variables were compared across severity strata using analysis of variance and the Student t-test, and categorical variables using the chi-square test, with $p < 0.05$ taken as significant. **Results:** The mean age was 55.3 years and 72 patients (60.0%) were male. Moderate ARDS predominated (62 patients, 51.7%), followed by severe (30, 25.0%) and mild (28, 23.3%), and ARDS was established within three days of the inciting event in 72 patients (60.0%). Pneumonia was the leading precipitant (45, 37.5%), followed by non-pulmonary sepsis (30, 25.0%), trauma (12, 10.0%), aspiration (10, 8.3%), acute pancreatitis (6, 5.0%) and drug overdose or toxin exposure (5, 4.2%); classical tropical infections accounted for fewer than 8% of cases. Cultures were sterile in 79 patients (65.8%) and no microbial agent was identified in 56 (46.7%). Etiology was significantly associated with severity grade ($p = 0.021$), as were increasing age ($p = 0.038$), lower SpO_2 ($p = 0.028$), higher respiratory rate ($p = 0.013$), acidaemia ($p = 0.024$), higher procalcitonin ($p = 0.01$) and NT-proBNP ($p = 0.001$), higher SOFA ($p = 0.003$) and NEWS ($p = 0.007$) scores, and lower Glasgow Coma Scale score ($p = 0.004$). **Conclusion:** In this urban tertiary ICU, ARDS was driven predominantly by pneumonia and sepsis rather than by classical tropical infections, and most patients presented with moderate or severe disease of rapid onset. The high proportion of culture-negative cases underlines an important diagnostic gap. Procalcitonin, NT-proBNP and bedside severity scores discriminated severity well and merit evaluation as practical risk-stratification tools in resource-constrained ICUs.

KEYWORDS

Acute Respiratory Distress Syndrome; Berlin Definition; Etiology; Intensive Care Unit; Procalcitonin; Sepsis; India

INTRODUCTION

Acute respiratory distress syndrome (ARDS) is a progressive form of lung injury characterized by immunological phenomenon leading to diffuse alveolar damage, arterial hypoxemia, and pulmonary edema, in the absence of cardiac failure. Ashbaugh and colleagues identified ARDS in 1967 and described this condition in 12 patients with acute respiratory failure refractory to oxygen therapy.[1] The etiology of ARDS can be divided into pulmonary/ direct cause and extra-pulmonary/ indirect causes. Pneumonia is the most common pulmonary cause and sepsis is the predominant extrapulmonary cause of ARDS.[2]

Both medical and surgical problems can cause ARDS. A significant proportion of medical cases in tropical regions are due to the endemic tropical infections. Mortality rates in the Northern, Southern and Western Indian population were 47.8%,2 36.6%4 and 57%5 respectively.[3] Acute respiratory failure may be defined as disruption in the function of the respiratory system that acutely impairs delivering adequate oxygen to or removing carbon dioxide from pulmonary capillary bed or both.[4]

It has varied etiology-related manifestations and has a high mortality. The diagnosis of respiratory failure relies primarily on arterial blood gas (ABG) analysis. Early diagnosis can be made by the physician who has a high index of suspicion and who is aware of the clinical situations in which respiratory failure is likely to be a complication.[5]

There are various causes of ARDS pneumonia, septicemia, aspiration of gastric, oral, or esophageal contents, major trauma, acute pancreatitis, transfusion associated acute lung injury (TRALI), drugs overdose, smoke inhalation, near drowning, shock, high altitude. ARDS is associated with several factors including air pollution, alcohol abuse, hypoalbuminemia, and cigarette smoking.[6]

If good clinical judgment and thorough knowledge of the natural history of the disease can be combined with a proper assessment of oxygenation, ventilation and acid base status, the management of many of patients can be exceptionally rewarding.[7]

Careful assessment of history, complete physical examination and evaluation of laboratory parameters may clarify the diagnosis. Serial assessments of sensorium, respiratory symptoms, ABG and response to treatment provide valuable clues to determine the need for intervention. Clinical signs of respiratory distress include tachypnea, altered depth of respiration, chest wall retraction, flaring of alae nasae, decreased breath sounds, grunting and cyanosis.[8]

In addition to cardiac signs like tachycardia, hypertension or bradycardia, hypotension and cardiac arrest can also be present. The diagnosis is confirmed by ABG. The recognition of respiratory failure as a life-threatening problem led to development of the concept of the intensive care unit (ICU) in modern hospitals. ICU personnel and equipment support vital functions to give patients' their best chance for recovery.[9]

Today's sophisticated ICU facilities with their novel mechanical life-support devices evolved as doctors and scientists learnt more and more about the cause of respiratory failure and how to treat it. In recent years, the rapid evolution of ICU has stimulated an increasing need to understand the types of patients cared for in such units, their outcome and the services they require.[10]

Understanding of the pathogenesis of ARDS has grown substantially over the last few decades. However, ARDS continues to be a major cause of morbidity and mortality in the critically ill. Plenty of work has been done on ARDS in western countries. Its incidence, clinical course, morbidity pattern, and outcome have been studied.[11-13]

The etiology of ARDS can be expected to be different in India due to the higher incidence of tropical infectious diseases[14]. However, not many studies have been done in India on ARDS. With this study, we aimed to evaluate the etiological profile of patients with ARDS in a tertiary care hospital in Jaipur, India. With Objectives: To study the etiological factors of ARDS in ICU settings, to study the demographic

profile of ICU-admitted ARDS patients.

MATERIALS AND METHODS

This was a hospital-based observational cross-sectional study conducted in the Department of General Medicine and Intensive Care Unit (ICU) at Sawai Man Singh (SMS) Medical College & Hospital, Jaipur, Rajasthan, a tertiary care referral center in North-West India.

Study Duration

The study was carried out over a period of 15 months, from October 2023 to December 2024.

Study Population

The study population comprised adult patients admitted to the ICU with a diagnosis of Acute Respiratory Distress Syndrome (ARDS) during the study period.

Sample Size

120 consecutive ARDS patients fulfilling the eligibility criteria were enrolled.

Sampling Technique

A consecutive sampling method was used. All patients admitted to the ICU with ARDS during the study period were screened, and those fulfilling the inclusion and exclusion criteria were recruited until the desired sample size was achieved.

Inclusion Criteria

Patients were included if they fulfilled all of the following criteria:

1. Age ≥18 years
2. Admission to ICU with a diagnosis of Acute Respiratory Distress Syndrome
3. Written informed consent obtained from the patient or legally authorized attendant
4. Diagnosis of ARDS based on the Berlin Definition, fulfilling all of the following:

- o Timing: Onset within 1 week of a known clinical insult or new/worsening respiratory symptoms
- o Chest imaging: Bilateral opacities on chest radiograph, not fully explained by effusions, collapse, or nodules
- o Origin of edema: Respiratory failure not fully explained by cardiac failure or fluid overload
- o Severity of hypoxemia (PaO_2/FiO_2 ratio):
- Mild ARDS: 200–300 mmHg
- Moderate ARDS: 100–200 mmHg
- Severe ARDS: ≤100 mmHg

Exclusion Criteria

- Patients not fulfilling the Berlin criteria for ARDS
- Patients or attendants refusing consent

Data Collection

Data were collected using a pre-designed structured proforma, which included:

- Demographic details (age, sex, religion, socioeconomic status, occupation)
- Clinical history and onset of symptoms
- Etiological factors leading to ARDS
- Physiological parameters (vital signs, oxygenation indices)
- Laboratory investigations (hematology, biochemistry, inflammatory markers)
- Microbiological investigations (sputum culture, blood culture)
- Severity scores (NEWS, SOFA, GCS)
- Radiological findings

Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants or their legally authorized representatives. Confidentiality of patient data was strictly maintained.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 25 (IBM Corp., USA) on Windows 11.

- Categorical variables were expressed as frequency and percentage
- Continuous variables were expressed as mean ± standard deviation (SD)
- Comparison of continuous variables between ARDS severity groups was done using Student's t-test or one-way ANOVA as appropriate
- Categorical variables were analyzed using the Chi-square test
- Pearson's correlation was used to assess the association between continuous variables
- A p-value <0.05 was considered statistically significant

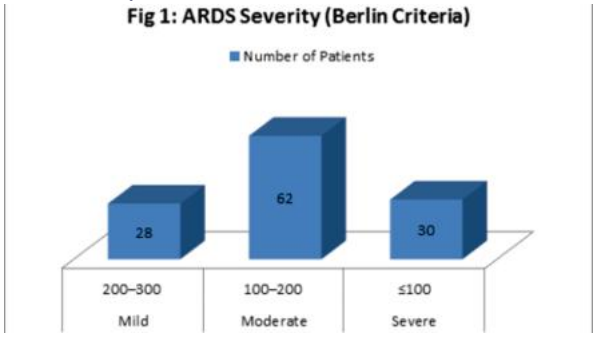
RESULTS

A total of 120 patients with ARDS were included in the study. The age of patients ranged from 18 to over 75 years, with a mean age of approximately 55 years. The largest proportion of patients belonged to the 46–60 years age group (33.3%), followed by 31–45 years (26.7%). Patients aged above 75 years constituted the smallest group (6.7%). This indicates a predominance of ARDS among middle-aged and elderly individuals.

Out of 120 patients, 72 (60%) were males and 48 (40%) were females, showing a clear male predominance among ARDS patients admitted to the ICU. More than half of the patients belonged to the middle socioeconomic class (51.66%), followed by the lower socioeconomic class (37.5%), while only 10.8% belonged to the upper socioeconomic group.

Religion-wise distribution showed that 75% were Hindu, followed by 16.7% Muslims, with Sikhs and other religions forming a small proportion. Laborers constituted the largest occupational group (27.5%), followed by unemployed individuals (20.8%), professionals (16.7%), retirees (14.2%), and business owners (12.5%). This reflects a higher burden of ARDS among economically active and vulnerable populations.

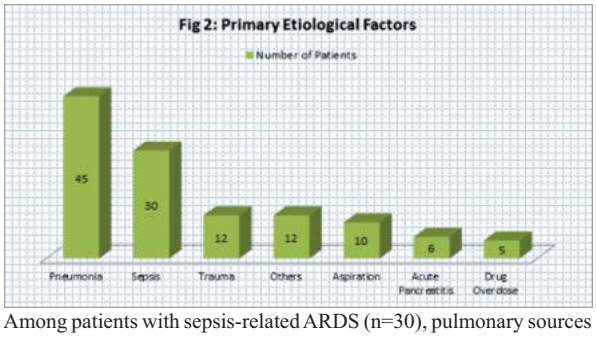
ARDS Severity and Onset



Regarding onset, 60% of patients developed ARDS within 3 days of admission or clinical insult, while the remaining 40% developed ARDS between 3–7 days, indicating an acute and rapidly progressive disease course in the majority.

Etiological Profile

The most common etiological factor identified was pneumonia (37.5%), followed by sepsis (25%). Other causes included trauma (10%), aspiration (8.3%), acute pancreatitis (5%), drug/toxin exposure (4.2%), and miscellaneous causes such as burns and transfusion-related acute lung injury (10%).



Among patients with sepsis-related ARDS (n=30), pulmonary sources were most common (50%), followed by abdominal (26.7%), urinary (16.7%), and soft tissue infections (6.7%).

Microbiological Findings

Culture positivity was observed in a minority of patients:

- Sputum culture positive: 16.7%
- Blood culture positive: 12.5%
- Both sputum and blood positive: 5%
- No growth: 65.8%

Bacterial pathogens were the most frequently identified organisms (33.33%), followed by viral infections (12.5%). Tropical infections such as scrub typhus (3.3%), dengue (2.5%), fungal infections (2.5%), and malaria (1.7%) were less common. Nearly 46.66% of patients had no identifiable microbial agent.

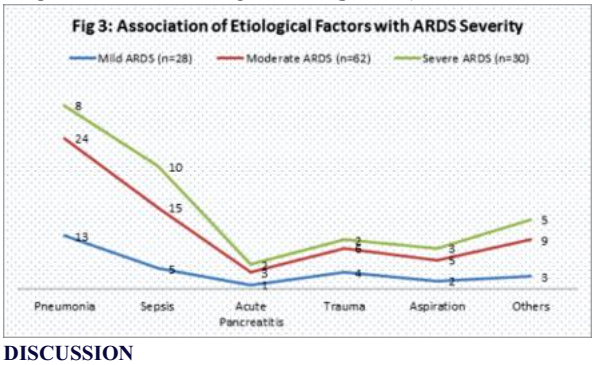
Table 1 Correlates of ARDS Severity & Clinical Parameters of Patients

Parameter	Mild ARDS	Moderate ARDS	Severe ARDS	p-value
Age	51.72±17.76	55.41±16.92	58.3±17.9	0.0137
Temp	99.5±1.34	99.6±.96	99.3±1.61	0.1722
SBP	122±39.14	121.1±43	122.92±35.3	0.7766
BDP	72±21.35	70.8±22.56	73.12±20.2	0.5074
MAP	89±26.6	86.9±28.6	90.73±24.7	0.3805
HR	106±22.1	108±20.7	105±23.3	0.4073
SPO2	88.14±8.19	83.5±8.53	82.8±7.91	0.028
RR	24.6±6.24	26.33±6.19	29±6.3	0.0127
Arterial PH	7.3±0.14	7.28±.15	7.12±.13	0.024
FiO2	49±19	50.51±17.7	48.25±20.18	0.4686
PaO2	100±55.2	106±68.9	95.6±38.2	0.2500
Na+	138±.12.89	140.7±8.39	136.3±15.73	0.0364
K+	4.03±0.76	4.07±.85	4.05±.68	0.8733
PCT	1.8±1.10	2.57±1.32	3.5±7.47	0.01
Day 1 Cr	0.99±.25	1.03±.25	1.05±.25	0.21
Neutrophils	83.75±12.63	84.9±10.86	82.65±14	0.2760
Lymphocytes	9.6±8.24	9.13±9.1	10±7.4	0.5202
WBC	15.41±9.07	16.48±8.63	14.4±9.41	0.1615
Hb	11.8±2.71	11.59±2.9	11.51±2.54	0.8574
Platelets	214.6±118.6	209.7±125.2	219±112.8	0.6330
HCT	38.66±8.94	37.41±9.11	36.88±8.84	0.7490
NEWS	9.81±2.99	10.48±2.79	11.9 ±3	0.0073
GCS	9.68±4.09	7.47±3.44	6.81±4.33	0.004
SOFA	4.69±2.95	7.43±2.7	8.6±3	0.0026
Lactate	2.54±2.27	2.55±2.14	2.53±2.4	0.9572
Albumin	3.09±.67	3.03±.73	3.14±.62	0.3203
S Ferritin	236.5±138.5	287±376	366±514	0.2878
SGOT	46.19±6.9	51±5.9	84±9.1	0.014
SGPT	42±4.1	40±8.5	71±6.0	0.01
S BILIRUBIN	1.51±2.11	1.56±2.53	1.46±1.65	0.7731
PROBNP	606±90.9	892±152	1035±168	0.001
pLOS	11.53±8.11	11.33±7.9	11.73±8.35	0.7640

Parameters such as temperature, blood pressure, heart rate, serum potassium, hemoglobin, platelet count, lactate, albumin, and duration of hospital stay did not show statistically significant variation across severity groups.

Association Analyses

- Age showed a significant association with ARDS severity (p=0.038), with older patients more likely to develop moderate to severe ARDS
- Gender was not significantly associated with ARDS severity (p=0.5)
- Etiological factors, particularly pneumonia and sepsis, were significantly associated with moderate to severe ARDS (p=0.021)
- Serum procalcitonin and NT-proBNP levels increased significantly with increasing ARDS severity
- Positive sputum cultures were significantly associated with pneumonia as the etiological factor (p=0.001)



DISCUSSION

Acute Respiratory Distress Syndrome (ARDS) remains a major cause of morbidity and mortality in critically ill patients despite advances in intensive care. The present cross-sectional study provides a comprehensive evaluation of the etiological spectrum, demographic profile, and clinical correlates of disease severity among ARDS patients admitted to a tertiary care ICU in North-West India.

Demographic Characteristics and ARDS Severity

The mean age of patients in this study was approximately 55 years, with the majority belonging to the 46–60-year age group. Increasing age was significantly associated with greater ARDS severity. This finding is consistent with large international cohorts such as the LUNG SAFE study, which reported a median age of 61 years and demonstrated worse outcomes with advancing age. Age-related decline in pulmonary reserve, higher burden of comorbidities, and impaired immune response likely contribute to increased severity among older patients.

A male predominance (60%) was observed, similar to previous global and Indian studies. However, gender was not significantly associated with ARDS severity, suggesting that although males are more frequently affected, disease progression and severity are independent of sex. This aligns with findings from multicentric ICU studies, which report male predominance without consistent gender-based differences in severity or outcomes.

Socioeconomic and Occupational Profile

Most patients belonged to the middle and lower socioeconomic strata, with laborers and unemployed individuals forming a substantial proportion. This reflects the patient profile of public sector tertiary hospitals in India and highlights the role of social determinants of health. Occupational exposure, delayed healthcare access, poor nutritional status, and higher prevalence of infections may predispose these populations to severe respiratory illnesses and subsequent development of ARDS.

Severity Pattern of ARDS

Using the Berlin definition, moderate ARDS was the most prevalent category, followed by severe and mild ARDS. This severity distribution is comparable to international data, although a slightly higher proportion of mild ARDS was noted in the present study. Early recognition, timely ICU admission, or differences in referral patterns may explain this observation. Nevertheless, the high burden of moderate-to-severe ARDS underscores the significant critical care demand imposed by this condition.

Etiological Profile

Pneumonia emerged as the leading cause of ARDS, followed by sepsis. This mirrors global epidemiological trends, where pulmonary infections remain the dominant trigger. The strong association of pneumonia and sepsis with moderate to severe ARDS observed in this study reinforces their role in driving extensive lung injury through inflammatory and endothelial pathways.

In contrast to studies from southern and eastern India that report a higher prevalence of tropical infections such as scrub typhus, leptospirosis, and malaria, these etiologies accounted for a relatively small proportion in the present cohort. This difference likely reflects geographical variation, urban setting, and regional disease epidemiology, emphasizing that ARDS etiology in India is not uniform and is strongly influenced by local infectious patterns.

Microbiological Findings and Diagnostic Challenges

A notable finding was the high proportion of culture-negative cases, despite clear clinical and radiological evidence of ARDS. This phenomenon has been reported in several international studies and may be attributed to prior antibiotic exposure, fastidious organisms, viral pathogens, or limitations in diagnostic modalities. Bacterial pathogens were the most commonly identified organisms, while viral and tropical infections constituted a smaller fraction.

The significant association between pneumonia and sputum culture positivity supports the infectious basis of pulmonary ARDS. However, the large diagnostic gap highlights the need for improved microbiological techniques, molecular diagnostics, and systematic pathogen identification strategies in critically ill patients.

Clinical Parameters and Inflammatory Markers

Several clinical and laboratory parameters demonstrated a significant association with increasing ARDS severity. Patients with severe

ARDS had lower oxygen saturation, higher respiratory rates, worsening metabolic acidosis, and higher illness severity scores (NEWS and SOFA), reflecting progressive respiratory and multi-organ dysfunction.

Inflammatory markers such as serum procalcitonin showed a stepwise increase with ARDS severity, indicating heightened systemic inflammation. Similarly, elevated NT-proBNP levels in severe ARDS suggest increased cardiac strain, possibly due to hypoxia-induced myocardial stress, pulmonary hypertension, or concomitant sepsis-related myocardial dysfunction. These findings support emerging evidence that ARDS is a systemic illness rather than an isolated pulmonary condition.

Elevated liver enzymes in severe ARDS further point toward multi-organ involvement, likely secondary to hypoxia, sepsis, or drug-related hepatotoxicity.

Clinical Implications

The findings of this study emphasize that pneumonia and sepsis remain the dominant and most severe precipitants of ARDS in urban tertiary care settings. Early identification of high-risk patients—particularly older individuals with elevated inflammatory markers and higher severity scores—may allow timely escalation of care, optimization of ventilatory strategies, and targeted management.

The association of procalcitonin and NT-proBNP with ARDS severity suggests potential utility of these biomarkers in risk stratification and prognostication, although their role requires further validation in prospective studies.

Limitations

This study has certain limitations. Being a single-center cross-sectional study, causal relationships and long-term outcomes could not be assessed. Advanced diagnostic tools for pathogen identification were not universally available, contributing to a high rate of culture-negative cases. Ventilator parameters and mortality outcomes were not analyzed, which could have provided additional prognostic insights.

CONCLUSION

In conclusion, ARDS in this tertiary care ICU was most commonly caused by pneumonia and sepsis, with moderate ARDS being the predominant severity category. Increasing age, higher inflammatory markers, elevated severity scores, and evidence of multi-organ dysfunction were strongly associated with severe ARDS. The etiological and clinical profile observed aligns with global trends while reflecting regional epidemiological variations. These findings underscore the importance of early diagnosis, etiological identification, and severity-based risk stratification to improve outcomes in ARDS patients.

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