ORIGINAL ARTICLE

Study of Outcome of Acute Respiratory Distress Syndrome in Intensive Respiratory Care Unit: A Single-center Study at a Tertiary Care Hospital

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Abstract

Background: Acute respiratory distress syndrome (ARDS) is a severe lung injury characterized by diffuse inflammation and hypoxemia. Despite advances in critical care, ARDS remains a significant cause of morbidity and mortality. This study evaluates the clinical profile, etiology, and outcomes of ARDS patients undergoing invasive ventilation (IV) and noninvasive ventilation (NIV) in a tertiary care setting.

Materials and methods: This observational study was conducted in the Department of Respiratory Medicine at a tertiary care hospital over 18 months (January 2023 to June 2024). Patients meeting the Berlin definition of ARDS and aged >12 years were included. Data collection encompassed demographics, clinical presentation, laboratory investigations, imaging, and ventilatory support. Statistical analysis included descriptive, comparative, and survival analyses using SPSS v21.

Results: The study included 100 patients, with a male predominance (75%). The mean age was 35.67 ± 14.88 years. The most common symptoms were fever (97%) and breathlessness (96%). Infectious etiology was identified in 66%, with leptospirosis (41%) being most prevalent. A total of 94% received NIV, and 47% required transition to IV. Mortality was significantly associated with invasive ventilation ($p < 0.001$). Kaplan–Meier analysis demonstrated significantly better survival in nonintubated patients ($p < 0.001$).

Conclusion: ARDS remains a critical illness with high mortality, particularly in IV patients. Identifying risk factors and optimizing noninvasive management may improve outcomes. Further studies are warranted to explore regional variations in etiology and management strategies.

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Introduction

Acute respiratory distress syndrome (ARDS) as a clinical condition has always been a physician's nightmare, given the high mortality rate despite the best available ventilatory strategies and improvement in our understanding over the past few decades. The diverse etiology leads to one common end result of extensive lung damage and noncardiogenic pulmonary edema, which carries a very high morbidity and mortality burden. It is characterized by diffuse inflammation within the lungs[1] resulting in severe hypoxemia and pulmonary infiltrates. Microscopically, it is marked by capillary endothelial injury and diffuse alveolar damage.[1] ARDS manifests within 7 days of the precipitating event. ARDS affects approximately three million patients annually worldwide, causing 75,000 deaths in developed countries.[2] Despite advancements in critical care, mortality remains high at 35–46%.[3,4] Hence, factors affecting the outcome might provide valuable insights to improve the outcomes and reduce the mortality. We therefore studied the factors affecting the outcome in ARDS in patients admitted to our tertiary care hospital.

Materials and Methods

This observational study was done in the Department of Respiratory Medicine at a tertiary care hospital over 18 months (January 2023 to June 2024), with approval from the Institutional Ethics Committee (IEC). The study aims to investigate factors that may affect outcomes, including etiology and clinical presentation. Further, it attempts to compare the different variables and outcomes between patients with invasive ventilation (IV) and noninvasive ventilation (NIV).

Patients presenting to the intensive respiratory care unit (IRCU) with ARDS, as defined by the Berlin criteria, and aged 12 years or older were included, whereas those who left against medical advice were excluded. The sample size was calculated using the formula: $n = [DEFF \times N \times p \times (1 - p)]/[d^2 \times (N - 1) + Z^2(1 - \alpha/2) \times p \times (1 - p)]$, where $N = 500$ (estimated annual IRCU ARDS cases), $p = 5.5\%$ (hypothesized frequency), $d = 4\%$ (confidence limits), $DEFF = 1$ (design effect), $Z = 1.96$ (for 95% confidence interval). The final sample size was 100, with an all-out sampling approach recruiting all eligible patients until the target was met.

Following a literature review, a pretested, prevalidated semistructured case record form was developed for data collection. Necessary approvals, including IEC clearance, were obtained before patient recruitment. Informed consent was secured before enrollment. Data collection encompassed sociodemographic details, clinical history, and systemic examination findings. Baseline investigations included complete blood count, arterial blood gas (ABG) analysis, serum electrolytes, liver and renal function tests, and infectious disease diagnostics (thick and thin smear for malarial parasites, ELISA for dengue IgM, Widal test, leptospirosis PCR, dengue PCR, and viral markers). Radiological and microbiological investigations, including chest X-ray, sputum examination, and blood culture sensitivity, were conducted. Details regarding hospitalization, ICU stay, ventilatory support, and mechanical ventilation settings (O_2 requirement, P/F ratio) were documented. Management strategies and patient outcomes (discharge or mortality) were recorded. All investigations were provided free of cost within the institution.

Data were entered, cleaned, and managed in Microsoft Excel (©Microsoft Inc.) and analyzed in SPSS v21 (©IBM Inc.). Mean and standard deviation (SD) (for continuous variables), median and interquartile range (IQR) (for categorical variables), and proportions (nominal data). The Shapiro–Wilk test was used to check normality ($p < 0.05$ considered non-normal). Pearson's Chi-square test ($p < 0.05$ significant) was used to determine associations, and Cramer's V

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assessed the strength of associations. An independent *t*-test (for parametric data) or Mann–Whitney *U* test (for nonparametric data) was used to compare different variables. A Kaplan–Meier curve was drawn for the survival analysis.

Results

The present study included 100 patients admitted to the intensive respiratory care unit (IRCU), yielding the following results. Out of 100 patients, 75% were males ($n = 75$), and 25% were females ($n = 25$). The male proportion was statistically significant (binomial test, $p < 0.001$). The mean ± SD age was 35.67 ± 14.88 years. Males had a mean age of 34.08 ± 14.26 years, whereas females had 40.44 ± 15.96 years. There was no significant difference between male and female age distributions (Mann–Whitney *U* test, $Z = -1.760$, $p = 0.078$). A total of 56% of patients reported addiction history, including alcohol (31%), smoking (20%), and tobacco use (19%). The mean duration of alcohol and tobacco use was 12.27 and 15.30 years, respectively. Smokers had a mean ± SD smoking index of 150.00 ± 57.74 and a mean ± SD of 15.42 ± 10.82 pack-years. The most common symptoms were fever (97%) and breathlessness (96%). Other symptoms included cough (55%), chest pain (4%), abdominal pain (4%), reduced urine output (1%), and sore throat (1%). Mean ± SD illness duration was 4.58 ± 2.07 days (excluding hospital stay). Of 100 patients, 66% had a confirmed infectious etiology, significantly higher than in those without a definite diagnosis (binomial test, $p < 0.001$). Leptospirosis was the most common infection (41%), followed by malaria (15%) and dengue (12%). One patient had both dengue and leptospirosis. A total of 94% of patients received NIV, significantly more than those who did not (binomial test, $p < 0.001$). Among them, 47% required invasive ventilation (IV). There was no significant difference between the IV and NIV groups (binomial test, $p = 0.617$). Mean ± SD duration of NIV was 2.46 ± 2.21 days, while for IV, it was 1.75 ± 3.66 days. A total of 61 patients required NIV for more than 1 day, and 26 required IV for more than 1 day. The majority (42%) of IV patients received volume-assisted control (VAC) ventilation. Positive end-expiratory pressure (PEEP) ($Z = 2.229$, $p = 0.328$), FiO_2 ($Z = 2.172$, $p = 0.337$), and PF ratio ($Z = 3.000$, $p = 0.233$) values did not change significantly from day 1 to day 7 (Friedman test) (Fig. 1).

The blood parameters were analyzed and mean ± SD values were calculated: hemoglobin: 10.62 ± 2.38 gm/dL; WBC: 9531.90 ± 5651.82 per mm^3; platelets: 79067 ± 87916 per mm^3; serum bilirubin: 2.99 ± 4.54 mg/dL; SGOT: 192.81 ± 756.88 IU/L; SGPT: 70.89 ± 88.29 IU/L; sodium: 133.68 ± 13.93 mEq/L; potassium: 3.96 ± 0.73 mEq/L; serum creatinine: 2.09 ± 0.50 mg/dL. Therefore, it was found that most of the blood parameters were disturbed.

Among patients, 26% had comorbidities, including hypertension (14%), diabetes mellitus (12%), COPD (5%), ischemic heart disease (3%), and hemophilia A (1%). A total of 54% had a history of severe organ failure or immunocompromised states. Tracheostomy was performed in 3% of patients, with a mean ± SD duration of 10.00 ± 9.90 days. The most common SPiRO score was 3 (44%). Mean ± SD APACHE-II score was 16.10 ± 8.33, with an estimated mortality of 27.68% ± 20.76% (Fig. 2). Mean ± SD A–a gradient difference was 249.32 ± 199.36.

Overall, survival and mortality rates were equal (50%). Among 94 patients who received NIV, 46.8% died, whereas all 6 who did not receive NIV died. No significant association was found between NIV and survival ($p = 0.112$). In contrast, invasive ventilation was significantly associated with mortality ($p < 0.001$; Cramer's V = 0.821). Among 47 IV patients, 93.6% died, whereas among 53 non-IV patients, 88.7% survived.

Mortality was significantly associated with male sex ($p = 0.038$), hemoptysis ($p = 0.032$), undiagnosed etiology ($p = 0.035$), invasive ventilation ($p < 0.001$), fever after admission ($p < 0.001$), and FiO_2 >50% ($p < 0.001$). Details of the association are given in Table 1.

Survivors had significantly higher mean values for duration of NIV, PF ratio on days 1, 3, and 7, PaO_2, SO_2, MAP, and pH. Nonsurvivors had significantly higher mean values for intubation duration, PEEP, FiO_2, SGPT, PCO_2, temperature, heart rate, respiratory rate, SPiRO score, APACHE-II score, estimated mortality, and A–a gradient difference. Details of the comparative analysis are given in Table 2. Kaplan–Meier survival analysis showed significantly better survival in patients not requiring IV (log-rank test, $\chi^2 = 2.525$, $p < 0.001$). Invasive ventilation had a hazardous effect on survival (Fig. 3).

Discussion

The ARDS definition has undergone several changes over the period of time as we have gained newer insights into the pathophysiology and management strategies. The newer modalities such as extracorporeal

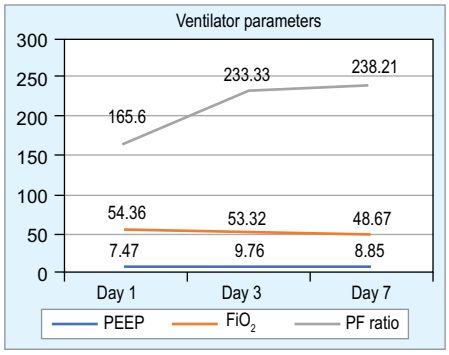

Fig. 1: Line graph showing ventilator parameters on days 1, 3, and 7

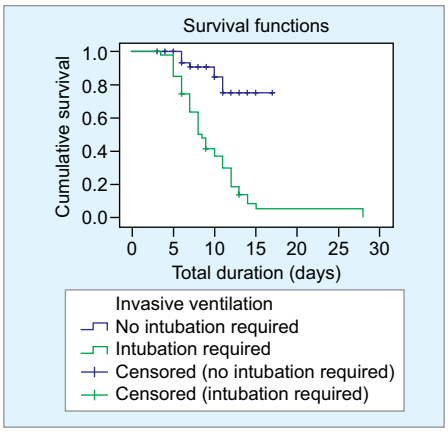

Fig. 3: Kaplan–Meier curve showing survival analysis of patients with IV and NIV

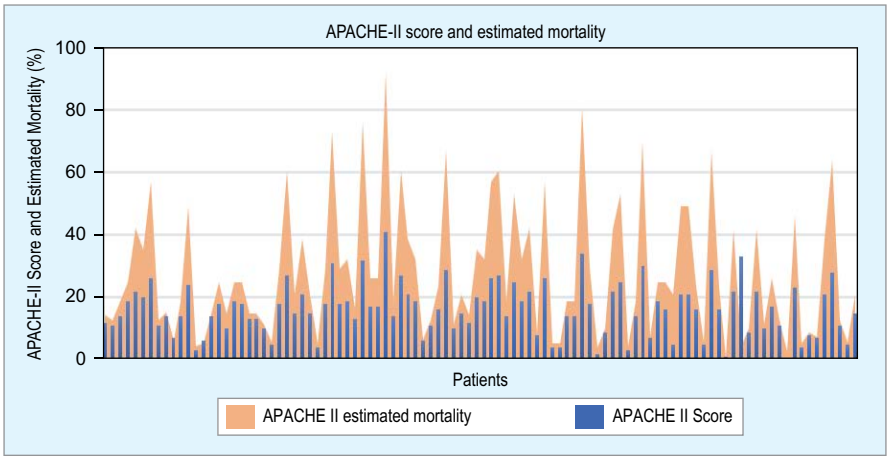

Fig. 2: Bar graph showing APACHE-II score and estimated mortality of all participants

Table 1: Association between final outcome and different variables

Variable		*Dead (%)*	*Discharged (%)*	*Chi-square test statistics*		
				χ2	*df*	*p-value*
Sex	Female	8 (32)	17 (68)	4.320	1	0.038
	Male	42 (58)	33 (44)			
Addiction	No	20 (46)	24 (54)	0.649	1	0.420
	Yes	30 (54)	26 (46)			
Alcoholism	No	30 (44)	39 (56)	3.787	1	0.052
	Yes	20 (65)	11 (35)			
Smoking	No	42 (53)	38 (47)	1.000	1	0.317
	Yes	8 (40)	12 (60)			
Tobacco	No	39 (48)	42 (52)	0.585	1	0.444
	Yes	11 (58)	8 (42)			
Fever	No	2 (67)	1 (33)	0.344	1	1.000
	Yes	48 (50)	49 (50)			
Breathlessness	No	2 (50)	2 (50)	0.000	1	1.000
	Yes	48 (50)	48 (50)			
Hemoptysis	No	29 (43)	39 (57)	4.596	1	0.032
	Yes	21 (66)	11 (34)			
Cough	No	25 (56)	20 (44)	1.010	1	0.315
	Yes	25 (46)	30 (54)			
Etiology	Unknown	22 (65)	12 (35)	4.456	1	0.035
	Infective	28 (42)	38 (58)			
NIV	No	6 (100)	0 (0)	3.840	1	0.112
	Yes	44 (47)	50 (53)			
Intubation (IV)	No	6 (11)	47 (89)	67.483	1	<0.001
	Yes	44 (94)	3 (6)			
Comorbidities	No	38 (51)	36 (49)	0.208	1	0.648
	Yes	12 (46)	14 (54)			
Steroids treatment	No	0 (0)	1 (100)	1.010	1	1.000
	Yes	50 (50)	49 (50)			
Platelet transfusion	No	23 (38)	38 (62)	9.458	1	0.002
	Yes	27 (69)	12 (31)			
FFP transfusion	No	24 (38)	39 (62)	9.653	1	0.002
	Yes	26 (70)	11 (30)			
Tracheostomy	No	47 (49)	50 (51)	3.093	1	0.242
	Yes	3 (100)	0 (0)			
Fever after admission	No	12 (25)	36 (75)	23.077	1	<0.001
	Yes	38 (73)	14 (27)			
Acute renal failure	No	12 (41)	17 (59)	1.214	1	0.271
	Yes	38 (54)	33 (46)			
FiO_2	<50%	12 (25)	37 (75)	25.010	1	<0.001
	>50%	38 (75)	13 (25)			
PaO_2	<50%	46 (50)	47 (50)	0.154	1	1.000
	>50%	4 (57)	3 (43)			

membrane oxygenator (ECMO), remain elusive to many institutes, and hence they need to heavily rely on optimal ventilatory management. The outcomes remain dismal, and therefore, there is a need to study and analyze the underlying risk factors that may contribute significantly to the high mortality burden. Studying and knowing them will help us formulate management strategies and put in place preventive measures, if feasible, so that the outcomes can improve.

The American-European Consensus Definition requires a pulmonary artery wedge pressure of <18 mm Hg, while the Berlin definition replaced this with imaging findings indicative of noncardiogenic pulmonary edema and a PaO_2/FiO_2 ratio <300 mm Hg.[1] In 2024, the definition incorporated high-flow nasal oxygen recipients, ultrasound for bilateral lung aeration loss, and $SpO_2/FiO_2 \leq 97\%$ as diagnostic criteria.[5] A new category for nonintubated patients receiving high-flow nasal oxygen at ≥30 L/min was added, and the PaO_2/FiO_2 ratio was excluded.[5] The etiology of ARDS is multifactorial, including pulmonary and extrapulmonary causes.[1] Pulmonary causes include lung infections

Table 2: Comparison between different variables based on final outcome

Variables	*Dead (mean)*	*Discharged (mean)*	*Test used*	*p-value*
Age (years)	36.38	34.96	Independent *t*-test	0.636
Duration of illness (days)	4.86	4.30	Independent *t*-test	0.176
Ventilator parameters				
Duration of NIV (days)	1.30	3.62	Independent *t*-test	<0.001
Duration of intubation (days)	3.17	0.34	Mann–Whitney *U* test	<0.001
PEEP on day 1	7.88	7.16	Independent *t*-test	0.049
PEEP on day 3	12.75	7.08	Independent *t*-test	0.038
PEEP on day 7	10.86	6.50	Independent *t*-test	0.003
FiO_2 on day 1	65.04	43.67	Mann–Whitney *U* test	0.001
FiO_2 on day 3	85.14	28.16	Mann–Whitney *U* test	< 0.001
FiO_2 on day 7	69.29	30.63	Independent *t*-test	0.004
PF ratio on day 1	133.24	197.96	Independent *t*-test	<0.001
PF ratio on day 3	108.76	326.40	Independent *t*-test	<0.001
PF ratio on day 7	182.29	294.14	Independent *t*-test	0.089
Blood parameters and clinical presentation				
Hemoglobin (mg/dL)	10.63	10.60	Independent *t*-test	0.947
WBC (per mm^3)	9693	9370	Independent *t*-test	0.777
Platelets (per mm^3)	83134	75000	Independent *t*-test	0.646
Bilirubin (mg/dL)	3.22	2.76	Mann–Whitney *U* test	0.407
SGOT (IU/L)	160.71	224.9	Mann–Whitney *U* test	0.234
SGPT (IU/L)	88.32	53.46	Mann–Whitney *U* test	0.041
PT	15.39	14.32	Independent *t*-test	0.150
INR	1.23	1.14	Independent *t*-test	0.200
Total protein (gm/dL)	6.20	5.87	Independent *t*-test	0.059
Albumin (gm/dL)	3.08	2.94	Independent *t*-test	0.212
Sodium (mEq/L)	132.08	135.28	Mann–Whitney *U* test	0.671
Potassium (mEq/L)	3.98	3.93	Mann–Whitney *U* test	0.541
ABG on admission	7.28	7.30	Independent *t*-test	0.870
PCO_2 (mm Hg)	40.04	32.14	Mann–Whitney *U* test	0.005
PaO_2 (mm Hg)	68.14	85.52	Independent *t*-test	0.037
HCO_3 (mEq/L)	17.89	18.63	Mann–Whitney *U* test	0.307
SO_2 (%)	81.90	90.52	Independent *t*-test	0.010
Temperature after admission (°F)	100.78	98.06	Independent *t*-test	<0.001
MAP (mm Hg)	74.40	97.20	Independent *t*-test	<0.001
pH	7.27	7.37	Independent *t*-test	<0.001
Hematocrit (%)	46.24	45.78	Independent *t*-test	0.820
WBC (per mm^3) after admission	6112	4967	Mann–Whitney *U* test	0.284
Sodium (mEq/L) after admission	134.64	135.32	Independent *t*-test	0.549
Potassium (mEq/L) after admission	3.95	3.91	Mann–Whitney *U* test	0.523
Heart rate (bpm)	114.14	93.86	Mann–Whitney *U* test	<0.001
Respiratory rate	28.24	23.88	Mann–Whitney *U* test	0.002
Special scores				
SPiRO score	2.72	1.66	Mann–Whitney *U* test	<0.001
APACHE II score	19.06	13.14	Independent *t*-test	<0.001
APACHE II estimated mortality	35.36	20.00	Independent *t*-test	<0.001
A–a gradient difference	328.38	170.25	Mann–Whitney *U* test	<0.001

and aspiration, while extrapulmonary sources encompass trauma, massive transfusion, sepsis, drowning, fat embolism, pancreatitis, drug overdose, and toxic fume inhalation.[1,6] These triggers initiate an inflammatory cascade, leading to pulmonary injury.[1,6] Risk factors include advanced age, female sex, alcoholism, smoking, cardiovascular surgery, traumatic brain injury, pancreatitis, pulmonary contusion, pneumonia, and drugs such as radiation therapy, chemotherapy, and amiodarone.[1,7]

Management focuses on reducing shunt formation, enhancing oxygen delivery, decreasing oxygen consumption, and preventing secondary injury.[1] Protective ventilatory strategies mitigate lung injury, while advanced techniques such as airway

pressure release ventilation (APRV), high-frequency oscillation ventilation (HFOV), continuous positive airway pressure (CPAP), and bi-level airway pressure (BiPAP) improve oxygenation.[1] Neuromuscular blockade is used to enhance lung compliance.[8] Nonventilatory interventions, including prone positioning, fluid management, and ECMO for refractory hypoxemia, have shown efficacy.[9–11] Glucocorticoids have limited roles, especially in late-stage ARDS and specific infections.[10]

Acute respiratory distress syndrome complications include high mortality, barotrauma due to high PEEP, prolonged mechanical ventilation, tracheostomy-related issues, nosocomial infections, pneumonia, sepsis, deep vein thrombosis, muscle weakness, antibiotic resistance, renal failure, and post-traumatic stress disorder.[1] Worldwide, ARDS is a major cause of morbidity and mortality, with variations in patient demography, risk factors, and treatment outcomes.

Our study showed a male predominance (75%), consistent with previous research attributing this to higher exposure to risk factors, e.g., smoking and alcohol consumption.[4,10–12] The mean patient age was 35.67 ± 14.88 years, slightly lower than that reported by George et al. (41.90 ± 15.35 years).[13] These demographic patterns may influence ARDS susceptibility and outcomes. Addiction was common, with 56% reporting substance use-alcohol (31%), smoking (20%), and tobacco (19%), with an average addiction duration of 12.27 years for alcohol and 15.30 years for tobacco. Comparatively, Yang et al. reported 35.7% alcohol addiction and 55.6% tobacco use among ARDS patients.[10] While substance abuse is a recognized risk factor, further studies are needed to assess the impact of addiction duration on ARDS outcomes. The clinical presentation varied, with fever (97%), breathlessness (96%), and cough (55%) being most common. Less frequent symptoms included chest pain, abdominal pain, and reduced urine output. Infective etiology was confirmed in 66% of cases, with leptospirosis (41%), malaria (15%), and dengue (12%) as primary causes. This contrasts with George et al., where scrub typhus was predominant, highlighting regional microbial differences.[13] Laboratory findings showed a mean hemoglobin of 10.62 gm/dL, WBC count of 9531.90 per mm^3, platelet count of 79067 per mm^3, and bilirubin of 2.99 mg/dL, with elevated SGOT and SGPT levels suggesting hepatic involvement. George et al. reported similar findings with a mean WBC of 10.891 per mm^3 and platelet count of 176.67 per mm^3.[13] These markers provide insights into ARDS-associated inflammation and coagulopathy.

Comorbidities were present in 26% of patients, with hypertension (14%), diabetes (12%), COPD (5%), and ischemic heart disease (3%) being the most common. Compared to Wang et al., who reported hypertension (22.1%) and chronic kidney disease (10.4%), this study observed a lower comorbidity burden.[14] Understanding the comorbidity impact on ARDS progression remains crucial. ABG analysis showed a mean pH of 7.29, $PaCO_2$ of 36.09 mm Hg, and PaO_2 of 76.83 mm Hg, consistent with Arsude et al., who analyzed ABG parameters at different ARDS stages.[15] ABG findings are key indicators of disease severity and guide respiratory management. Tracheostomy was performed in 3% of cases. Mechanical ventilation remains central, with lung-protective strategies crucial to preventing ventilator-induced lung injury (VILI) through low tidal volume ventilation and optimal PEEP.[16] While prone positioning improves oxygenation and survival in severe ARDS, ECMO remains debated due to limited supporting evidence.[11,17] The mortality rate was 50%, with an APACHE-II score average of 16.10 ± 8.33 and an estimated mortality rate of 27.68 ± 20.76%. Bellani et al. linked worsening ARDS severity with increased mortality, reduced ventilator-free days, and prolonged ICU stays.[3] Mortality was significantly associated with male sex, hemoptysis, unknown etiology, invasive ventilation, and FiO_2 >50%. Logistic regression identified altered sensorium and inotrope use as poor outcome predictors, reinforcing the need for early risk stratification.[13]

Noninvasive ventilation was used in 94% of patients, with 47% requiring subsequent intubation. NIV failure was associated with poorer outcomes, consistent with Arsude et al., who reported respiratory improvements following NIV in selected cases.[15] However, whether NIV failure independently predicts mortality remains debated, as it may reflect disease severity. Survivors had significantly shorter intubation duration, lower PEEP, FiO_2, and APACHE-II scores, indicating the adverse impact of prolonged mechanical ventilation. Increased ARDS severity correlated with advanced age, elevated heart rate, greater FiO_2 requirements, and longer ventilation duration, consistent with prior studies.[13] Infective etiology was associated with longer hospital stays, and survival rates were significantly higher when the etiology was known.

This study provides valuable findings into ARDS clinical profiles, etiologies, and outcomes. Early risk identification, targeted infection management, and individualized ventilatory support remain key to improving patient outcomes. Further large-scale, multicentric studies are needed to optimize ARDS management, particularly in resource-limited settings.

Conclusion

In our setting, leptospirosis was the leading cause of ARDS. Mortality correlated with male sex, hemoptysis, unknown etiology, invasive ventilation, and FiO_2 >50%, while altered sensorium and inotrope use independently predicted poor outcomes, emphasizing the need for early risk assessment to guide treatment strategies. Survival was higher with noninvasive ventilation than with invasive ventilation, and survivors had significantly lower intubation duration, PEEP, FiO_2, and APACHE-II scores, highlighting the adverse effects of prolonged mechanical ventilation. Our findings reinforce the need for randomized controlled trials to explore therapeutic approaches beyond ventilatory management to improve outcomes.

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