Research Article

Clinical Profile and Outcomes of Patients Requiring Invasive Mechanical Ventilation in a Medical ICU: A Prospective Observational Study from Central India

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Background: Invasive mechanical ventilation (IMV) is a cornerstone of critical care, yet data from medical ICUs in resource-limited settings in central India remain sparse. We aimed to characterise the clinical profile, complications, and outcomes of patients requiring IMV in a tertiary care medical ICU.

Methods: A prospective observational study was conducted in the Medical ICU (MICU) of a tertiary care hospital in central India, from 2023–2026. Adults (>12 years) requiring IMV for ≥24 hours were enrolled consecutively (n=143). Demographics, comorbidities, primary diagnosis, SOFA score, GCS, ABG parameters, ventilator settings, complications, and ICU outcomes were systematically recorded. Statistical analysis used the chi-square test, independent t-test, Mann–Whitney U test, and Kaplan–Meier survival analysis.

Results: Mean age was 55.92 ± 17.06 years; 69.9% were male and 62.9% from rural areas. Leading diagnoses were COPD/asthma exacerbation (16.1%), pneumonia (15.4%), and stroke (15.4%). Mean SOFA score was 8.8 ± 3.1 and mean GCS was 8.6 ± 4.5. Airway protection was the primary indication for IMV in 53.1% of cases. Lung-protective ventilation (tidal volume 6.0 ± 0.2 mL/kg PBW) was applied in 97.9%. Overall ICU mortality was 58.0%. Mortality ranged from 0% in seizures to 91.7% in meningoencephalitis. Higher SOFA score was a significant predictor of mortality in sepsis ($p = 0.020$), ACS/cardiogenic shock ($p = 0.040$), stroke ($p = 0.030$), and uremic encephalopathy ($p = 0.010$). Ventilator-associated pneumonia (VAP) occurred in 10.5% overall and was markedly higher in non-survivors (16.9 *vs* 1.7%). Admission SOFA score, serum lactate, and VAP were independent predictors of ICU mortality.

Conclusions: IMV carries high mortality in this Indian MICU, particularly in neurological emergencies and sepsis. SOFA score, serum lactate, and VAP are key prognostic determinants. Consistent lung-protective ventilation and VAP prevention are feasible and critical in resource-limited Indian settings. These data provide locally relevant benchmarks for clinical practice and quality improvement.

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Keywords: Mechanical ventilation; MICU; SOFA score; VAP; ICU mortality; India; resource-limited setting; lung-protective ventilation

Introduction

Invasive mechanical ventilation (IMV) is an essential life-support intervention in the Medical Intensive Care Unit (MICU). Common indications include acute respiratory failure, sepsis, ARDS, acute exacerbations of COPD, cardiogenic pulmonary oedema, and neurological emergencies requiring airway protection. Despite advances in ventilatory strategy and critical care medicine, ICU mortality among mechanically ventilated patients remains high—often exceeding 30 to 50% in published cohorts.1,2

Mortality is shaped by baseline characteristics, primary diagnosis, admission severity, ventilator management quality, and iatrogenic complications such as ventilator-associated pneumonia (VAP) and barotrauma. High SOFA and APACHE II scores, sepsis or shock, vasopressor requirements, and complication onset are consistently identified as potent mortality predictors.3,4 However, existing data from low- and middle-income countries (LMICs), including India, are hampered by small sample

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sizes, narrow disease focus, incomplete comorbidity documentation, and variable reporting of ventilation practices and complication rates.5

Within India, published IMV literature derives predominantly from large urban tertiary hospitals. Data from smaller referral hospitals serving rural and semi-urban communities where disease profile, age at presentation, and severity at admission differ substantially are almost entirely absent. There is a particular lack of data from Madhya Pradesh and central India.

This prospective observational study addresses these gaps by providing the first systematic documentation of clinical profile, illness severity, complications, and outcomes from a tertiary MICU in Madhya Pradesh. Our objectives were to: (1) characterise demographics, comorbidities, and primary diagnoses; (2) assess illness severity using SOFA score and GCS; (3) document ABG parameters and laboratory findings at admission; (4) record duration of IMV and ICU stay across diagnostic categories; and (5) examine the association of clinical, laboratory, and severity parameters with patient outcome.

Methods

Study Design and Setting

This was a hospital-based, prospective observational study conducted in the MICU of a government-affiliated tertiary teaching hospital in central India, serving a predominantly rural population. The study was conducted over a minimum period of one year following Institutional Ethics Committee (IEC) approval (in accordance with the Declaration of Helsinki and ICMR guidelines for biomedical research). No intervention was introduced; patients received standard care per departmental protocols.

Study Population

All adults (>12 years) admitted to the MICU and requiring IMV for ≥24 hours were enrolled consecutively. Exclusion criteria included: age ≤12 years; IMV <24 hours (including early self-extubation or death within 24 hours); patients managed on non-invasive ventilation only; and refusal of written informed consent.

Sample Size

The minimum sample size was calculated using the formula for estimation of a population proportion (reference: VAP prevalence ~50%; Vora *et al*., 2015), requiring n=119. After a 10% attrition allowance, the targeted minimum was 133; 143 patients were ultimately enrolled.

Data Collection

A pre-designed structured case record proforma captured: sociodemographic data; presenting complaints and comorbidities (hypertension, diabetes mellitus, COPD/asthma, CAD/IHD, CHF, CKD, liver disease/cirrhosis, prior stroke/TIA, and malignancy); vital signs; primary diagnosis; indication for intubation; initial ventilator parameters (mode, tidal volume, respiratory rate, PEEP, FiO_2); ABG analysis (pH, PaO_2, $PaCO_2$, HCO_3^-, SpO_2); laboratory investigations (CBC, RFT, LFT, serum lactate); SOFA and GCS scores; complications (VAP, barotrauma, VILI/new ARDS); duration of IMV and ICU stay; and outcome (survived/died).

Definitions

SOFA score was calculated at initiation of mechanical ventilation across six organ systems (maximum 24); score bands of 0–5, 6–8, 9–11, 12–14, and ≥15 were used for mortality stratification. The P/F ratio was derived from direct ABG-measured PaO_2 where available, or estimated from SpO_2 *via* the Severinghaus equation with pH correction (Kelman formula). VAP was defined per CDC/NHSN criteria: pneumonia after >48 hours on IMV, with new radiological infiltrates plus ≥2 of: fever/hypothermia, leukocytosis/leukopenia, or purulent secretions. Sepsis and septic shock were defined per Sepsis-3 consensus definitions (Singer *et al*., JAMA 2016).

Statistical Analysis

Quantitative data were summarised as mean ± SD or median (IQR). Categorical variables were compared using chi-square or Fisher's exact test. Continuous variables between groups were compared using the independent t-test or Mann–Whitney U test as appropriate. Kaplan–Meier survival curves were compared using the log-rank test. A *p-value* <0.05 was considered statistically significant.

Results

Patient Demographics

Of 143 patients enrolled, mean age was 55.92 ± 17.06 years (median 60 years; range 16–89). The largest age group was 60–74 years (57 patients, 39.9%), followed by 45–59 years (34 patients, 23.8%) (Table 1). Males constituted 69.9% (n=100) and most patients came from rural areas (62.9%; n=90), consistent with the hospital's role as a tertiary referral centre serving a predominantly rural catchment.

Comorbidities

Hypertension was the most prevalent comorbidity (38.5%), followed by COPD/asthma (28.7%), type 2

Table 1: Demographic and baseline clinical profile

Variable	*Value*
Age, mean ± SD (years)	55.92 ± 17.06
Age group 60–74 years, n (%)	57 (39.9%)
Male sex, n (%)	100 (69.9%)
Rural residence, n (%)	90 (62.9%)
SOFA score, mean ± SD	8.8 ± 3.1 (median 9; range 3–18)
GCS, mean ± SD	8.6 ± 4.5 (median 8)
Sepsis/shock at admission, n (%)	100 (69.9%)
Vasopressor support at admission, n (%)	35 (24.5%)
Dialysis/RRT at admission, n (%)	9 (6.3%)

diabetes mellitus (17.5%), CAD/IHD (16.1%), prior stroke/TIA (13.3%), chronic heart failure (11.2%), chronic kidney disease (10.5%), liver disease/cirrhosis (9.8%), and malignancy (7.0%).

Primary Diagnoses and Indications for IMV

The three most frequent primary diagnoses were COPD/asthma exacerbation (16.1%), pneumonia (non-COVID, 15.4%), and stroke (15.4%), followed by ACS/HF/cardiogenic pulmonary oedema (11.9%), sepsis/septic shock (9.1%), hepatic encephalopathy (8.4%), meningoencephalitis (8.4%), poisoning/trauma/HIE (6.3%), seizures (4.9%), and uremic encephalopathy (4.2%). The primary indication for IMV was airway protection/other in 53.1%, hypoxic respiratory failure in 28.0%, and hypercapnic respiratory failure in 18.9% (Table 2).

Admission Severity, Vitals, and Laboratory Parameters

Mean SOFA score was 8.8 ± 3.1 (range 3–18); 36.4% of patients scored in the 6–8 band and 30.8% in the 9–11 band. Mean GCS was 8.6 ± 4.5. Admission vital signs showed tachycardia (mean HR 103.1 ± 22.3 bpm). ABG analysis revealed a mean arterial pH of 7.29 ± 0.18 (acidaemia), mean PaO_2 of 74.2 ± 44.7 mmHg, mean $PaCO_2$ of 44.8 ± 24.3 mmHg, mean HCO_3^- of 20.9 ± 9.1 mmol/L, and a mean P/F ratio of 121.4 ± 51.3 (indicating moderate-to-severe oxygenation impairment). Laboratory findings included mean haemoglobin 10.9 ± 3.0 g/dL, leukocyte count 16.6 ± 15.5 ×10^3/mm^3, serum creatinine 3.35 ± 7.36 mg/dL, blood urea 92.0 ± 82.5 mg/dL, and serum lactate 2.85 ± 3.18 mmol/L.

Ventilator Settings

Volume Assist-Control (VAC) mode was used in 97.9% of patients. Mean tidal volume was 6.0 ± 0.2 mL/kg PBW (lung-protective strategy), mean set respiratory rate 18.0 ± 0.2 breaths/min, mean PEEP 6.0 ± 0.2 cmH_2O, and mean initial FiO_2 99.3 ± 5.9%.

Duration of IMV and ICU Stay

Overall mean IMV duration was 5.7 ± 4.4 days (median 4 days; range 2–23 days). Neurological conditions required the longest ventilatory support: poisoning/trauma/HIE (7.8 ± 7.9 days), stroke (7.1 ± 4.2 days), and meningoencephalitis (6.8 ± 5.7 days). Shortest durations were seen in seizures (3.4 ± 1.8 days) and hepatic encephalopathy (3.9 ± 2.3 days). Mean ICU stay was 7.4 ± 5.0 days (median 6 days), consistently exceeding IMV duration, indicating continued monitoring after extubation.

ICU Outcomes

Overall ICU mortality was 58.0% (83/143). Mortality varied widely: from 0% in seizures (0/7) to 91.7% in meningoencephalitis (11/12). Other high-mortality groups were poisoning/trauma/HIE (88.9%), sepsis/septic shock (76.9%), and hepatic encephalopathy (75.0%). The lowest

Table 2: IMV duration and ICU mortality by primary diagnosis

Primary Diagnosis	*n (%)*	*IMV Days (Mean ± SD)*	*ICU Days (Mean ± SD)*	*Mortality (%)*
COPD/Asthma exacerbation	23 (16.1%)	5.2 ± 3.3	7.1 ± 5.3	43.5%
Pneumonia (non-COVID)	22 (15.4%)	6.2 ± 5.0	8.3 ± 5.1	63.6%
Stroke	22 (15.4%)	7.1 ± 4.2	7.7 ± 4.4	54.5%
ACS/HF/Cardiogenic oedema	17 (11.9%)	5.3 ± 4.6	6.8 ± 4.8	35.3%
Sepsis/Septic shock	13 (9.1%)	4.8 ± 2.6	6.3 ± 1.5	76.9%
Hepatic encephalopathy	12 (8.4%)	3.9 ± 2.3	7.3 ± 3.7	75.0%
Meningoencephalitis	12 (8.4%)	6.8 ± 5.7	9.5 ± 7.4	91.7%
Seizures	7 (4.9%)	3.4 ± 1.8	3.9 ± 2.0	0.0%
Uremic encephalopathy	6 (4.2%)	4.5 ± 1.6	7.0 ± 3.8	50.0%
Poisoning/Trauma/HIE	9 (6.3%)	7.8 ± 7.9	7.8 ± 7.9	88.9%
Overall	143 (100%)	5.7 ± 4.4	7.4 ± 5.0	58.0%

mortality aside from seizures was ACS/HF/cardiogenic oedema (35.3%).

SOFA Score and Mortality

A clear stepwise mortality gradient was observed with increasing SOFA score: 47.4% (SOFA 0–5), 50.0% (6–8), 54.5% (9–11), 86.4% (12–14), and 83.3% (≥15). SOFA score was significantly higher in non-survivors across several diagnostic categories: sepsis/septic shock (10.40 ± 2.67 *vs* 7.00 ± 1.73; $p = 0.020$), ACS/HF/cardiogenic shock (10.33 ± 1.75 *vs* 7.55 ± 2.84; $p = 0.040$), stroke (9.67 ± 3.42 *vs* 7.20 ± 1.14; $p = 0.030$), and uremic encephalopathy (12.33 ± 0.58 *vs* 10.00 ± 1.00; $p = 0.010$).

ABG Parameters and Outcome

In sepsis/septic shock, non-survivors had significantly lower baseline PaO_2 (60.08 ± 19.25 *vs* 84.67 ± 5.86 mmHg; $p = 0.010$). In uremic encephalopathy, non-survivors had markedly lower arterial pH (6.81 ± 0.08 *vs* 7.11 ± 0.16; $p = 0.03$) and serum HCO_3^- (5.50 ± 1.22 *vs* 12.67 ± 5.69 mmol/L; $p = 0.04$), reflecting severe metabolic acidosis. In stroke, non-survivors had a significantly higher $PaCO_2$ (39.75 ± 10.23 *vs* 31.13 ± 4.67 mmHg; $p = 0.030$). Serum lactate was consistently higher in non-survivors across most diagnostic groups, though most individual differences did not reach significance.

Complications

VAP occurred in 15 patients (10.5%), barotrauma in 3 (2.1%), and VILI/new ARDS in 1 (0.7%). VAP was strongly associated with non-survival: 16.9% of non-survivors developed VAP compared to 1.7% of survivors. VILI/new ARDS occurred exclusively in non-survivors. Three independent predictors of ICU mortality were identified: admission SOFA score ($p = 0.001$), serum lactate ($p = 0.027$), and development of VAP ($p = 0.008$).

Discussion

This prospective study of 143 mechanically ventilated adult MICU patients in central India provides locally relevant epidemiological and prognostic benchmarks. The mean age of 55.92 years and male predominance (69.9%) are consistent with reported patterns in Indian and LMIC ICU cohorts.23,24 The predominance of rural patients (62.9%) underscores the role of the study hospital as a critical regional referral centre.

Respiratory conditions (COPD/asthma exacerbation, pneumonia) and neurological emergencies (stroke, encephalopathies, meningoencephalitis) were the leading causes of IMV, reflecting regional disease burden. This pattern aligns with Yasar *et al*. (2024), who reported respiratory diseases (33.7%) and neurological conditions (19.8%) as the two most common admission diagnoses in mechanically ventilated patients.23 Hypertension (38.5%), COPD/asthma (28.7%), and diabetes mellitus (17.5%) as the leading comorbidities are consistent with the existing literature.3,5

The mean SOFA score of 8.8 (indicating moderate-to-severe organ dysfunction) and mean GCS of 8.6 (reflecting significant neurological compromise) document the high severity of illness at admission. The stepwise mortality gradient with increasing SOFA bands—from 47.4% (score 0–5) to 86.4% (score 12–14)—confirms SOFA as a strong prognostic tool in this setting, consistent with reported sensitivity of 83.9% and specificity of 69.9% for mortality prediction in Indian ICU cohorts.4 Significant SOFA–outcome associations were confirmed in sepsis, ACS/cardiogenic shock, stroke, and uremic encephalopathy.

Overall ICU mortality of 58.0% is consistent with, though at the upper end of, published ranges for LMICs (29–63%). Meningoencephalitis (91.7%) and poisoning/trauma/HIE (88.9%) showed the highest mortality, reflecting the lethality of severe CNS infection with systemic sepsis and the limited resource availability for advanced neuromonitoring and neuroprotective interventions. Notably, zero mortality was observed in seizures—reflecting the inherent reversibility of ventilatory support in status epilepticus when airway protection is the primary indication.

Uniform application of lung-protective ventilation (tidal volume 6.0 ± 0.2 mL/kg PBW; 97.9% of patients) was associated with very low rates of barotrauma (2.1%) and VILI/new ARDS (0.7%), validating this strategy as both safe and feasible in a resource-limited Indian MICU. Mean IMV duration (5.7 ± 4.4 days) and ICU stay (7.4 ± 5.0 days) align with comparable Indian and international cohorts.

VAP was the most important modifiable complication, occurring in 10.5% overall but in 16.9% of non-survivors versus only 1.7% of survivors—and independently predicting mortality. This is consistent with the strong association of VAP with mortality reported by Yasar *et al*. (49.5% in deceased *vs* 9.8% in survivors).23 Admission SOFA score and serum lactate were the other two independent predictors of ICU mortality in this cohort.

In uremic encephalopathy, non-survivors exhibited profound metabolic acidosis (pH 6.81; HCO_3^- 5.50 mmol/L), demonstrating the critical importance of renal function and acid-base status as prognostic determinants in this subgroup. The paradoxical finding of lower age in non-survivors with hepatic encephalopathy (40.78 *vs* 59.00

years; $p = 0.01$) likely reflects the severity of underlying liver disease rather than age per se.

Limitations

This study has several limitations. First, as a single-centre study, findings may not be generalisable to all Indian or LMIC settings with differing disease profiles and resources. Second, small case numbers within individual diagnostic subgroups limited the statistical power for subgroup mortality analyses. Third, long-term post-discharge outcomes (quality of life, cognitive function, post-intensive care syndrome) were not assessed, limiting understanding of late morbidity. Future multicentre prospective studies with standardised data collection and long-term follow-up are warranted.

Conclusions

This prospective observational study provides the first systematic epidemiological and prognostic dataset from a tertiary MICU in central India. IMV carries high mortality (58.0%) in this resource-limited setting, with neurological emergencies and sepsis bearing the greatest burden. SOFA score, serum lactate, and VAP are key independent predictors of ICU mortality. Consistent lung-protective ventilation is safe and feasible. Targeted VAP prevention, rigorous haemodynamic monitoring—particularly in sepsis, cardiogenic shock, and neurological emergencies—and early identification of patients with rising SOFA scores represent the most actionable quality improvement targets. These findings establish locally relevant benchmarks and provide a foundation for protocol optimisation and future investigator-initiated research in this under-studied region.

Ethical Approval

Ethical approval was taken from the institutional ethical review board IEC-RDGMC (IEC Ref no. PG/GENERAL MEDICINE/30/2024).

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