

# The predictive ability of SAPS II, APACHE II, SAPS III, and APACHE IV to assess outcome and duration of mechanical ventilation in respiratory intensive care unit

Ravi Dosi<sup>1</sup>, Gaurav Jain<sup>1</sup>, Nirmal Jain<sup>2</sup>, Kamendra Singh Pawar<sup>1</sup>, Jayeeta Sen<sup>3</sup>

<sup>1</sup>Department of Respiratory Medicine, SAMC and PGI, Indore, Madhya Pradesh, India, <sup>2</sup>Department of Critical Care, Sharda Hospital and Medical College, Greater Noida, Uttar Pradesh, India, <sup>3</sup>Department of Radiation Oncology, SAMC and PGI, Indore, Madhya Pradesh, India

## ABSTRACT

**Objectives:** The objective is to determine utility of SAPS II, APACHE II, SAPS III, and APACHE IV scoring system in assessing outcome in mechanically ventilated patients in respiratory intensive care unit and to predict duration of mechanical ventilation (MV). **Materials and Methods:** A prospective observational study where 83 mechanically ventilated patients were grouped into Group 1 ( $n_1 = 40$ , NIV) and Group 2 ( $n_2 = 43$ , Invasive ventilation) was conducted. SAPS II, APACHE II, SAPS III, and APACHE IV scores based predicted mortality (PM) were collected at day 1, and day 3. Outcomes (on day 7) were grouped into negative and positive. (NIV-negative outcome = Home NIV, intubation or death; positive outcome = NIV free. Invasive group-positive outcome = Extubation; negative outcome = Death). Binary logistic regression was applied to predict duration of MV ( $>$  or  $<$  5 days). **Results:** The data were analyzed using SPSS version 17.0 trials comparisons of PM on day 1 with SAPS II ( $P < 0.05$ ) and APACHE IV ( $P < 0.007$ ) were significant predictors of clinical outcomes in Group 1 where as in Group 2, none of the system could predict significantly. On day 3, Group 1 analysis revealed SAPS II ( $P < 0.002$ ), SAPS III ( $P < 0.03$ ), and APACHE IV ( $P < 0.004$ ) based PM as significant predictors of outcome. APACHE II ( $P < 0.05$ ) and APACHE IV ( $P < 0.02$ ) PM were significant in Group 2. On day 3, APACHE IV could significantly predict ( $P < 0.05$ ) duration of MV ( $>5$  or  $<$  5) while A-a gradient ( $P < 0.09$ ) predicted poorly in Group 1. In Group 2, APACHE IV was a poor predictor ( $P < 0.09$ ). Two full logistic regression models were also formulated for both the groups. **Conclusion:** Study concludes that day 3 severity scores are more significant predictors of outcome and duration. APACHE IV scoring system was found more effective than other systems, not only significantly differentiating outcomes of MV but also predicting duration of NIV.

**KEY WORDS:** APACHE II, APACHE IV, duration of mechanical ventilation, outcome of mechanical ventilation, SAPS II, SAPS III

**Address for correspondence:** Dr. Gaurav Jain, Siddhant Hostel, SAIMS, Indore - 452 001, Madhya Pradesh, India.  
E-mail: jaingrv@gmail.com

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## INTRODUCTION

Respiratory failure is the one of the most frequent indication of mechanical ventilation (MV); also pulmonary

diseases constitute the most common comorbidities on mechanical ventilation.<sup>[1-3]</sup>

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Despite advances in therapeutic interventions, mortality has remained high over the years.<sup>[4]</sup> If outcome and duration of invasive ventilation can be foreseen, early interventions like tracheostomy in case of prolonged MV can be planned which might help in preventing mortality, reducing cost, and counseling patients and relatives. Moreover, there are no standard guidelines to wean off non-invasive ventilation; this leads to prolong use of NIV resulting in extended hospital stay, higher chances of HAI and also cost of healthcare.<sup>[5]</sup>

Need for a validated indicator to evaluate MV practices has become important in current scenario. Scoring systems have long been used to evaluate delivery of healthcare and to predict outcome of critically ill patients. This study was undertaken to evaluate, if existing severity scores namely SAPS II, APACHE II, SAPS III, and APACHE IV could predict outcome and duration of MV.

## MATERIALS AND METHODS

A comparative study was conducted in respiratory intensive care unit (ICU) of a tertiary care center in Central India, over a period of 1 year 2018–2019. Patients >18 years of age, excluding pregnant women and children, who underwent MV for respiratory failure due to various underlying pulmonary etiologies. Out of total ( $n = 83$ ), 40 patients required noninvasive ventilation (Group 1 = 40) whereas forty three required invasive ventilation (Group 2 = 43). SAPS II, APACHE II, SAPS III, and APACHE IV scores based predicted mortality (PM) were collected at day 1, and day 3 [Figure 1].

Outcomes were analyzed on day 7 being grouped into negative and positive. Negative outcomes for NIV were patient ending on domiciliary NIV therapy, intubation or death during the course of NIV or continuation of NIV at day 7; whereas positive outcome being freedom from NIV. For Group 2, positive outcome was extubation success; whereas negative were death, extubation failure or continuation of therapy at day 7.

The data were analyzed using SPSS Statistics for windows, version 17 (SPSS INC., Chicago, Illinois, USA) trials. Descriptive and inferential statistics were used. Results for continuous variables presented as mean  $\pm$  standard deviation while categorical presented in numbers (%). This was assumed that the observations recorded for a continuous variable had followed a normal distribution.

Significance of scoring systems PM (%) on day 1 and 3 between outcomes (positive/negative) on day 7 was identified using *t*-test. The  $P \leq 0.05$  was considered as significant while  $P \leq 0.01$  and above were considered as highly/strongly significant.

Binary logistic regression was used to predict the days of MV of studied mechanically ventilated patients

of Group 1 (noninvasive) and Group 2 (invasive) by employing age, sex, gradient, PaO<sub>2</sub>/FiO<sub>2</sub> ratio, SAPS II, APACHE II, SAPS III, and APACHE IV scoring systems PM (percentage) to model the prediction of days of MV.

## RESULTS

Out of a total patients, 65 were (78.3%) male while rests (18, 21.7%) were female. The mean age (mean  $\pm$  standard deviation) of all mechanically ventilated patients ( $n = 83$ ) was  $54.20 \pm 13.06$  years, observed within ranges from 18 to 85 years.

Acute exacerbation of chronic obstructive pulmonary disease was found to be the most common diagnosis in Group 1, whereas bacterial pneumonia in Group 2 [Table 1].

Comparisons of PM (%) on day 1 revealed that the severity scoring systems SAPS II and APACHE IV significantly differentiated between clinical outcomes on day 7 among patients supported with noninvasive (Group 1) ventilator. Among patients of Group 2, only APACHE IV-based PM produced acceptable results, such that PM of negative outcome was higher, but did not reach the statistical significance [Table 2].

Comparisons of PM (%) on day 3 among severity scoring systems revealed that the scoring systems SAPS II, APACHE II and APACHE IV had significantly differentiated clinical outcomes in Group 1 on day 7. Among patients of group 2, comparisons of PM (%) on day 3 revealed that the severity scoring systems SAPS III and APACHE IV PM (%) on day 3 had significantly differentiated clinical outcomes on day 7 [Table 3].

Since more number of scoring systems was found significant on day 3 in differentiating outcome in Group 1 and Group 2, day 3 scores were used to predict duration of MV. A cut off point for duration of MV (2–14 days) in mechanically ventilated patients ( $n = 83$ ) on noninvasive ( $n_1 = 40$ ) and invasive ( $n_2 = 43$ ) ventilators was projected by subtracting  $2 \times SE$  (0.606 days) from mean duration of MV ( $5.08 - 0.606 = 4.474$  days). To avoid fractions and for simplification, the approximate figure of 5 days was considered as cut off point for the duration of MV.

Tables 4 and 5 report the analysis of binary logistic regression to predict the days of MV of studied patients of Group 1 (noninvasive) and Group 2 (invasive) by employing age, sex, gradient, ratio of partial pressure of oxygen (PaO<sub>2</sub>), and fraction of inspired oxygen (FiO<sub>2</sub>), SAPS II, APACHE II, SAPS III, and APACHE IV PM (%) at day 3 model the prediction of days of MV.

Logistic model for the duration of MV (non-invasive) showed that the severity and mortality predictor system APACHE IV to be the significant predictor ( $P < 0.05$ ) of

**Table 1: Diagnosis among mechanically ventilated patient of two groups**

Diagnosis of mechanically ventilated patient	Noninvasive (Group 1) n (%)	Invasive (Group 2)
	n <sub>1</sub> =40, n (%)	n <sub>2</sub> =43, n (%)
Acute exacerbations of chronic obstructive pulmonary disease	14 (35.0)	9 (20.9)
Post tuberculosis chronic obstructive pulmonary disease	2 (5.0)	2 (4.7)
Viral pneumonia	5 (12.5)	10 (23.3)
Bacterial pneumonia	5 (12.5)	14 (32.6)
Aspiration pneumonia	0 (0.0)	2 (4.7)
Disseminated tuberculosis	0 (0.0)	1 (2.3)
Noncardiogenic pulmonary edema	1 (2.5)	1 (2.3)
Interstitial lung disease	3 (7.5)	1 (2.3)
Chronic obstructive pulmonary disease with bronchiectasis	5 (12.5)	1 (2.3)
Posttuberculosis chronic obstructive Pulmonary disease with posttuberculosis bronchiectasis	3 (7.5)	1 (2.3)
Chronic obstructive pulmonary disease with community-acquired pneumonia	2 (5.0)	1 (2.3)

**Table 2: Comparison of baseline SAPS II, SAPS III, APACHE II, and APACHE IV predicted mortality (%) at day 1 between outcomes (positive/negative) on day 7**

Group and severity scoring system		(n) D1	Outcome at day 7	Scatter (%) Mean±SD	Mean difference (%)	t-statistic	P (LOS)
Noninvasive ventilation (Group 1)	SAPS II PM (%) on D1	19	Negative	13.91±7.89	4.67	2.04	P<0.05*
		21	Positive	9.24±6.56			
	SAPS III PM (%) on D1	19	Negative	18.74±10.28	2.55	0.95	P>0.05 <sup>⊙</sup>
		21	Positive	16.19±6.38			
	APACHE II PM (%) on D1	19	Negative	26.95±11.71	5.38	1.62	P>0.05 <sup>⊙</sup>
		21	Positive	21.57±9.20			
	APACHE IV PM (%) on D1	19	Negative	11.21±8.32	5.96	2.83	P<0.00 <sup>#</sup>
		21	Positive	5.24±4.68			
Invasive ventilation (Group 2)	SAPS II PM (%) on D1	19	Negative	27.58±17.41	6.60	1.11	N/A
		24	Positive	34.18±20.71			
	SAPS III PM (%) on D1	19	Negative	24.42±14.16	8.63	1.86	N/A
		24	Positive	33.05±15.77			
	APACHE II PM (%) on D1	19	Negative	31.35±14.80	6.03	1.26	N/A
		24	Positive	37.38±16.25			
	APACHE IV PM (%) on D1	19	Negative	27.21±18.69	4.26	0.75	P>0.05 <sup>⊙</sup>
		24	Positive	22.95±18.36			

<sup>#</sup>The differences are highly significant at the 0.007 level of significance. <sup>^</sup>The differences are poorly/suggestively significant at the 0.07 level of significance. \*The mean difference is significant at the 0.03 level of significance. <sup>⊙</sup>The differences are not (insignificant) significant at the 0.05 level of significance. The degrees of freedom are 38 and 41. PM: Predicted mortality, LOS: Level of significance, NA: Not available, SD: Standard deviation

**Table 3: Comparison of baseline SAPS II, SAPS III, APACHE II, and APACHE IV predicted mortality (%) at day 3 between outcomes (positive/negative) on day 7**

Group and severity scoring system		(n) D3	Outcome at day 7	Scatter (%) Mean±SD	Mean difference	t-statistic	P (LOS)
Noninvasive Ventilation (Group 1)	SAPS II PM (%) on D1	13	Negative	13.51±7.68	6.54	3.31	P<0.002 <sup>#</sup>
		21	Positive	6.97±3.86			
	SAPS III PM (%) on D1	13	Negative	19.09±14.69	5.38	1.44	P>0.05 <sup>⊙</sup>
		21	Positive	13.71±6.99			
	APACHE II PM (%) on D1	13	Negative	26.31±8.24	6.36	2.32	P<0.03*
		21	Positive	19.95±7.49			
	APACHE IV PM (%) on D1	13	Negative	11.22±9.35	7.18	3.11	P<0.004 <sup>#</sup>
		21	Positive	4.04±3.99			
Invasive Ventilation (Group 2)	SAPS II PM (%) on D1	13	Negative	34.01±23.20	11.92	1.61	P>0.05 <sup>⊙</sup>
		24	Positive	22.09±20.49			
	SAPS III PM (%) on D1	13	Negative	35.77±21.68	13.64	2.13	P<0.05*
		24	Positive	22.13±16.71			
	APACHE II PM (%) on D1	13	Negative	42.35±23.18	10.76	1.47	P>0.05 <sup>⊙</sup>
		24	Positive	31.59±20.26			
	APACHE IV PM (%) on D1	13	Negative	35.31±25.12	18.01	2.58	P<0.02*
		24	Positive	17.30±17.21			

<sup>#</sup>The differences are highly significant at the 0.004 and 0.007 levels of significance. \*The mean difference is significant at the 0.02, 0.03 and 0.05 levels of significance. <sup>⊙</sup>The differences are not (insignificant) significant at the 0.05 level of significance. The degrees of freedom are 32 and 35. PM: Predicted-mortality; LOS: Level of significance, SD: Standard deviation

duration of MV while Alveolar–Arterial Gradient ( $P < 0.09$ ) predicted poorly whereas age, sex (male), and rest three

severity scoring systems were confirmed insignificant predictors of duration of MV.

**Table 4: Significance of prediction of duration of mechanical ventilation among patients supported with noninvasive (Group 1) ventilator at day 3**

Parameters and scoring system predicted mortality at day 3	β	SE	P (LOS)	Odds ratio	95% CI	
					Upper	Lower
Age (year)	0.058	0.047	P>0.05 <sup>⊙</sup>	1.059	0.966	1.162
Sex (male)	-0.117	1.234	P>0.05 <sup>⊙</sup>	0.890	0.079	9.994
Gradient	0.008	0.004	P<0.09 <sup>^</sup>	1.008	0.999	1.016
PaO <sub>2</sub> /FiO <sub>2</sub> ratio	-0.001	0.002	P>0.05 <sup>⊙</sup>	0.999	0.994	1.003
SAPS II (predicted mortality %)	-0.061	0.122	P>0.05 <sup>⊙</sup>	0.940	0.741	1.194
APACHE II (predicted mortality %)	-0.069	0.064	P>0.05 <sup>⊙</sup>	0.933	0.824	1.057
SAPS III (predicted mortality %)	-0.051	0.093	P>0.05 <sup>⊙</sup>	0.951	0.792	1.142
APACHE IV (predicted mortality %)	-0.203	0.101	P<0.05 <sup>*</sup>	0.817	0.670	0.996

\*The test variable is significant at the 0.05 level of significance. <sup>⊙</sup>The test variable is not (insignificant) significant at the 0.05 level of significance. <sup>^</sup>The test variable is poorly/suggestively significant at the 0.07 level of significance. LOS: Level of significance, CI: Confidence interval, SE: Standard error

**Table 5: Significance of prediction of duration of mechanical ventilation among patients supported with invasive (Group 2) ventilator at day 3**

Parameters and scoring system predicted mortality at day 3	β	SE	P (LOS)	Odds ratio	95% CI	
					Upper	Lower
Age (year)	0.007	0.042	P>0.05 <sup>⊙</sup>	1.007	0.928	1.093
Sex (male)	-0.584	1.059	P>0.05 <sup>⊙</sup>	0.558	0.070	4.443
Gradient	0.000	0.005	P>0.05 <sup>⊙</sup>	0.999	0.990	1.009
PaO <sub>2</sub> /FiO <sub>2</sub> ratio	0.001	0.008	P>0.05 <sup>⊙</sup>	1.001	0.986	1.017
SAPS II (predicted mortality, %)	0.091	0.063	P>0.05 <sup>⊙</sup>	1.095	0.969	1.239
APACHE II (predicted mortality, %)	-0.068	0.055	P>0.05 <sup>⊙</sup>	0.934	0.839	1.040
SAPS III (predicted mortality, %)	0.027	0.034	P>0.05 <sup>⊙</sup>	1.027	0.962	1.098
APACHE IV (predicted mortality, %)	-0.063	0.037	P<0.09 <sup>^</sup>	0.939	0.874	1.009

\*The test variable is significant at the 0.05 level of significance. <sup>⊙</sup>The test variable is not (insignificant) significant at the 0.05 level of significance. <sup>^</sup>The test variable is poorly/suggestively significant at the 0.07 level of significance. LOS: Level of significance, CI: confidence interval, SE: Standard error

Logistic model for the duration of MV (invasive) showed that the severity and mortality predictor system APACHE IV to be the poorly significant predictor (P < 0.09) of duration of MV whereas age, sex (male), ratio of PaO<sub>2</sub> and FiO<sub>2</sub>, and rest three severity scoring systems were confirmed insignificant predictors of duration of MV.

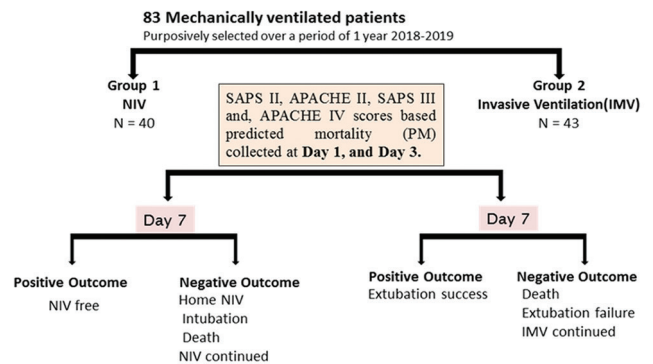
The individual full logistic regression model for the duration of noninvasive MV <5 and ≥5 days is as follows;

Log odds of duration of MV (noninvasive) = 0.079 + 0.058 × Age (year) - 0.117 × Sex (1 If Male and 0 If female) + 0.008 × Gradient (score) - 0.001 × ratio of PaO<sub>2</sub> and FiO<sub>2</sub> (ratio) - 0.061 × SAPS II (mortality %) - 0.069 × APACHE II (mortality %) - 0.051 × SAPS III (mortality %) - 0.203 × APACHE IV (mortality %).

The probability of correct prediction was found to be 55.9%. However, the sensitivity of prediction (≥5 days) found to be 89.5% as compared to specificity of prediction (<5 days) was 66.7%.

The individual full logistic regression model for duration of invasive MV <5 and ≥5 days is as follows;

Log odds of duration of MV (invasive) = 0.375 + 0.007 × Age (year) - 0.584 × Sex (1 If Male and 0 If female) + 0.000 × Gradient (score) + 0.001 × ratio of PaO<sub>2</sub>



**Figure 1: Study scheme**

and FiO<sub>2</sub> (ratio) + 0.091 × SAPS II (mortality %) - 0.068 × APACHE II (mortality %) + 0.027 × SAPS III (mortality %) - 0.063 × APACHE IV (mortality %).

The probability of correct prediction found to be 56.8%. However, the sensitivity of prediction (≥5 days) found to be 76.2% as compared to specificity of prediction (<5 days) was 62.5%.

**DISCUSSION**

Clinical outcome is an important measure of efficacy of MV applied to the patients. Our study have attempted to predict outcome and duration of MV by means of existing severity scoring systems, demographic characters,

and ventilatory parameters. Scoring systems have not been validated in predicting outcome and duration of mechanically ventilated patients in larger Indian scenario.<sup>[6]</sup>

The presence of validated indicators of outcome and duration of invasive and non-invasive MV for Indian population, will not only result in better patient care, but also in proper utilization of resources, and will also bring uniformity and standardization of practice patterns in ICU.<sup>[7]</sup>

In our study, severity scores found at day 3 of initiation of therapy were found to be more significant predictors of outcome as compared to severity scores at initiation, which was also found in study by Hira and Mittal.<sup>[8]</sup>

APACHE IV scoring system was found more effective than other systems, not only significantly differentiating outcomes of MV but also predicting duration of NIV, which may be the result of consideration of use MV and including a disease specific reason for admission in its risk prediction.<sup>[9]</sup> The disadvantages of APACHE IV scoring system in an Indian scenario would be higher data abstraction time as compared to other systems, with additional requirement of resources.<sup>[10]</sup>

Interestingly, SAPS II was also found as a significant indicator of outcomes of NIV group on day 1 and day 3, which correlates with previous studies.<sup>[11-13]</sup>

Therefore, our study suggests APACHE IV as a better predictor of outcome and duration of MV, though this work is preliminary with potential limitations such as being a single center study with very small sample size.

## CONCLUSION

The study concludes that day 3 severity scores are more significant predictors of outcome. APACHE IV scoring system was found more effective than other systems, not

only significantly differentiating outcomes of MV but also predicting duration of NIV.

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## Conflicts of interest

There are no conflicts of interest.

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