

**Central Venous Oxygen Saturation as a Predictor of the Outcome of Weaning from Mechanical Ventilation**Vandana Sharma<sup>1</sup>, Vicky Bakshi<sup>2</sup>, Vikesh Bhatt<sup>3</sup><sup>1</sup>Assistant Professor, Department of Anaesthesiology and Critical Care, VCSGGIMS&R, Srinagar, Uttarakhand, India<sup>2</sup>Assistant Professor, Department of Respiratory Medicine, VCSGGIMS & R, Srinagar, Uttarakhand, India<sup>3</sup>Assistant Professor, Department of Orthopaedics, VCSGGIMS & R, Srinagar, Uttarakhand, India

Received: 01-12-2022 / Revised: 30-01-2023 / Accepted: 27-02-2023

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Conflict of interest: Nil

**Abstract:****Objectives:** The present study was to compare the chances of extubation failure after mechanical ventilation using conventional vs central venous oxygen saturation criteria for weaning from long term mechanical ventilation and to establish a more reliable criteria for extubation of long term mechanically ventilated patients.**Methods:** Patients who were fulfilling the weaning criteria were weaned using two stage approach: viz evaluation of the indicators of extubation outcome followed by SBT for 30 minutes. Measurements of hemodynamics (blood pressure, heart rate, and respiratory rate) and Scvo2 were registered at 1<sup>st</sup> minute of spontaneous breathing trial. Patients were put on T- piece and observed for 30 minutes and, at 30<sup>th</sup> minute again the conventional criteria and central venous sample was taken. Conventional parameters and Central venous oxygen saturation (Scvo2) readings at the 1<sup>st</sup> minute of spontaneous breathing and after 30 minutes of spontaneous breathing trial were noted.**Results:** 52 patients were studied out of which 25 patients were extubated by standard extubation criteria and 27 patients were extubated according to SCvO2 criteria and conventional criteria combined together. ScVO2 of patients with failed extubation trial in group B. the mean ScVO2 at 1 minute was found to be 69 % and at 30 minutes it was 63.16%. The difference in ScVO2 at 1 and 30 minutes was 5.54%. Diagnostic accuracy of central venous oxygen saturation (ScVo2) in predicting extubation success. It was found that ScVO2 has a sensitivity of 95.4%, specificity of 100%, positive predictive value of 100%, negative predictive value of 83.3% and an accuracy of 96.3% and the graph below shows the area under ROC curve.**Conclusions:** Scvo2 criteria when added to conventional criteria helps the clinician to estimate proper time for extubation and reduce the rates of reintubation. The previous studies also have revealed that fall in Scvo2 by more than 4% from baseline values at 30 minutes of SBT have higher chances of extubation failure.**Keywords:** Mechanical Ventilation, Conventional Parameters, Central Venous Oxygen Saturation.

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**Introduction**

The term weaning is defined as the gradual process of decreasing ventilator support. It is estimated that 40% of the duration of mechanical ventilation is dedicated to the process of weaning [1].

One of the questions that needs to be addressed after putting the patient on ventilator is when the patient will be ready for weaning and how to perceive it. Various factors are involved in the determination of whether the patient is ready to be weaned from ventilator and also in prediction of weaning process. There have always been complications and prolonged hospital stay (along with higher rates of morbidity and mortality) associated with both premature and delayed weaning. Delayed weaning leads to ventilator associated lung injury, ventilator associated pneumonia, and ventilator induced

diaphragmatic dysfunction[2,3] and premature weaning leads to complications like: loss of airway, defective or inefficient gas exchange, aspiration and respiratory muscle fatigue[4,5].

Weaning covers the entire process of disengaging the patient from mechanical support and endotracheal tube, including relevant aspects of terminal care. Weaning procedure usually starts only after the underlying disease process that necessitated mechanical support has significantly improved or is resolved [6]. The patient should have an adequate gas exchange, appropriate neurological and muscular status and stable cardiovascular function [6]. Extubation failure (EF) occurs in approximately 20-32% of the patients meeting the conventional predictors[7]. Presence of cardiovascular

dysfunction can contribute to weaning failure by increasing loads and decreasing neuromuscular capacity. Although respiratory muscles do not develop fatigue as they perform huge workload[8] but they rely on efficient oxygen transport on cardiovascular system[9]. Studies have shown that patients who failed weaning also failed to increase oxygen delivery (DO<sub>2</sub>) to the tissues in part due to elevated right and left ventricular after loads.

Central venous oxygen saturation[10] is being currently studied and used to guide extubation in patients on ventilator for more than 48 hours and there have been good results and lesser chances of reintubation than using only the conventional methods. In an attempt to reduce the chances of extubation failure during weaning process using conventional parameters we decided to use central venous oxygen saturation as an additional guide to extubation in our unicentric study done at surgical ICU of SMHS hospital. The present study was to Compare the chances of extubation failure after mechanical ventilation using conventional vs central venous oxygen saturation criteria for weaning from long term mechanical ventilation and to establish a more reliable criteria for extubation of long term mechanically ventilated patients.

#### Material & Methods

This unicentric clinical study conducted in the Postgraduate, Department of Anaesthesiology and Critical Care and was performed in Surgical Intensive Care Unit (SICU) at SMHS hospital after approval by the Institutional Ethical Committee. The informed consent was taken from all the patients or next of kin.

#### Exclusion Criteria

- a) Tracheostomised patients
- b) Patients with no central venous catheter
- c) Negative for informed consent
- d) Intolerance to first spontaneous breathing trial.

All patients under this study who were mechanically ventilated for more than 48 hours in surgical ICU at Government Medical College Srinagar were prospectively followed. They were assessed daily for the presence of following readiness to wean criteria:

- a) Improvement in the underlying condition that led to respiratory failure.
- b) Adequate oxygenation as indicated by PaO<sub>2</sub> >60 mmHg on fI<sub>O</sub><sub>2</sub> <40% and positive end expiratory pressure of <8 cm H<sub>2</sub>O.
- c) Cardiovascular stability (heart rate <130 beats / minute and no or minimal pressor support
- d) Afebrile
- e) Adequate hemoglobin (>8gm/dl)
- f) Adequate mental status (arousal, Glasgow coma scale >13, no continuous sedative infusion)

- g) Effective cough
- h) Normal acid base and electrolytes

Demographic data, routine laboratory investigations (complete blood picture, liver and kidney function tests and electrolytes) and chest radiographs were collected at admission. Vital signs, mechanical ventilation days and days in ICU were registered as well.

Enrolled patients were evaluated daily for the presence of weaning criteria. Patients fulfilling these criteria were weaned using two stage approach: viz evaluation of the indicators of extubation outcome followed by SBT for 30 minutes.

After patients were assessed for readiness to wean, central venous sample was taken at 1minute of putting patients on T-piece trial. Arterial sample from radial artery was also collected simultaneously as a part of conventional management.

Sampling of Scvo<sub>2</sub> was carried out using catheter threaded through internal jugular vein into right atrium, which was already in situ during the course of ICU stay.

Patients who successfully tolerated the trial were extubated and then observed in next 48 hours for the presence of any adverse events and respiratory failure.

Failure of extubation was meant that there was need to re-intubate the patient within two days of extubation process.

Measurements of hemodynamics (blood pressure, heart rate, and respiratory rate) and Scvo<sub>2</sub> were registered at 1<sup>st</sup> minute of spontaneous breathing trial. Patients were put on T- piece and observed for 30 minutes and, at 30<sup>th</sup> minute again the conventional criteria and central venous sample was taken.

After observing the patients during the 30 minute period and rechecking the parameters, all the preparations were made for the reintubation. Equipment and drugs were kept ready, proper oral suctioning was done and supplemental oxygen source including noninvasive ventilation device was kept ready. After checking requisite parameters again, patients were extubated and reassured. Supplemental oxygen was given by weaning devices. Some patients needed NIV during weaning period, repeat blood gas sampling was taken at 15 and 30 mins. Patients were observed for 48 hours for any signs of respiratory distress, fall in GCS, fall in oxygen saturation or increase in work of breathing. Conventional relevant lab investigations were also checked and repeated during that 48 hour period as per ICU protocol.

Conventional parameters and Central venous oxygen saturation (Scvo<sub>2</sub>) readings at the 1<sup>st</sup> minute

of spontaneous breathing and after 30 minutes of spontaneous breathing trial were noted in subjects under study and results were subjected to statistical analysis.

**Statistical Analysis**

Data was analysed with the help of SPSS version 22.0 software. Descriptive data are demonstrated as percentage or mean ± SD.  $\chi^2$  and Fisher’s exact tests were utilized for the analysis of categorical variables, as appropriate. Mean differences between the investigated variables were assessed by

independent *t*-test or Mann-Whitney *U*-test according to the normality of the data. P- value was taken less than or equal to 0.05 ( $p \leq 0.05$ ) was statistical significance.

**Observations & Results**

In our study fifty two patients were studied out of which 25 patients were extubated by standard extubation criteria and 27 patients were extubated according to SCvO<sub>2</sub> criteria and conventional criteria combined together.

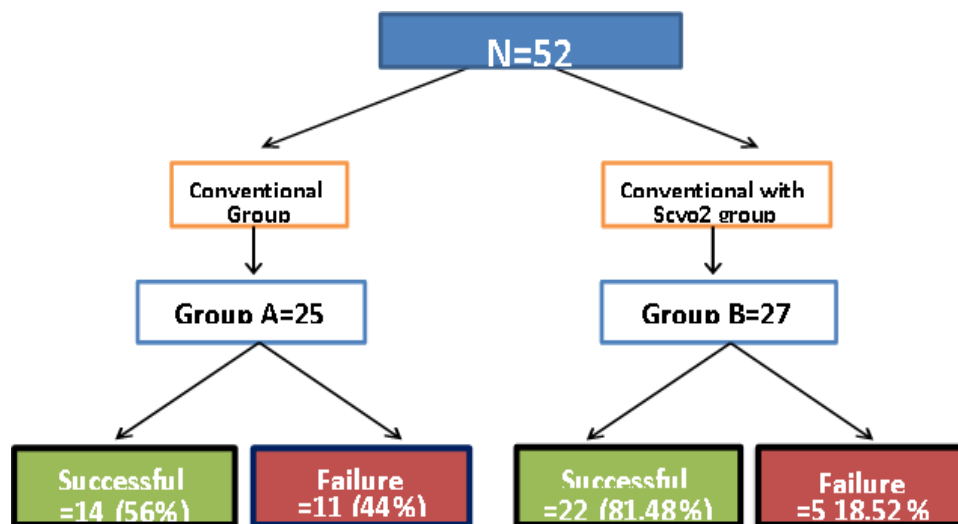


Figure 1:

Table 1: Age distribution of study patients in two groups

Age (Years)	Group A		Group B		P-value
	No.	%age	No.	%age	
20-29	8	32	8	29.6	0.652
30-39	7	28	6	22.2	
40-49	2	8	3	11.1	
50-59	3	12	4	14.8	
≥ 60	5	20	6	22.2	
Total	25	100	27	100	
Mean±SD (Range)	40.9±17.02 (20-70)		43.1±15.96 (22-70)		

The age distribution of patients in groups A and B. The mean difference of age in the two groups was found to be statistically insignificant.

Table 2: Gender distribution of study patients in two groups

Gender	Group A		Group B		P-value
	No.	%age	No.	%age	
Male	11	44	17	63.0	0.171
Female	14	56	10	37.0	
Total	25	100	27	100	

In the present study, the gender distribution of patients in groups A and B. The difference between the two groups was found to be statistically insignificant.

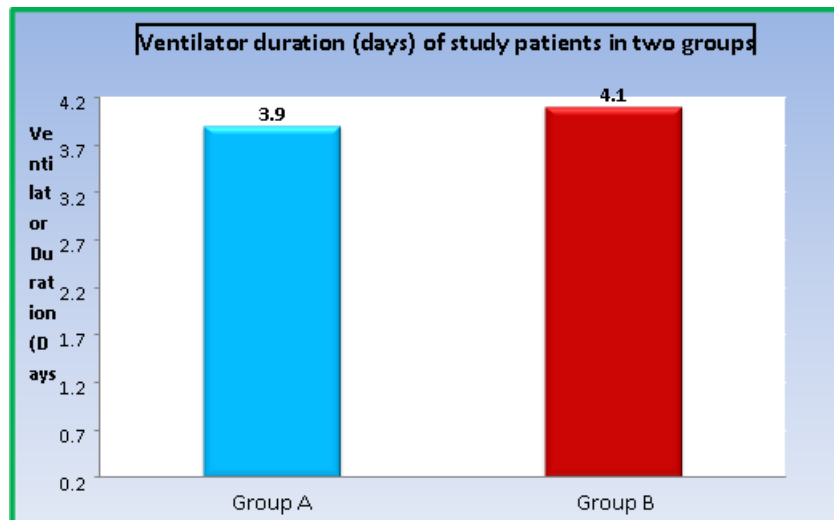


Figure 2:

The duration of ventilation in patients of both study groups. The difference in the ventilation days between the two groups was found to be statistically insignificant.

Table 3: Comparison based on vitals in two groups at 1 minute after SBT

Parameter	Group A		Group B		P-value
	Mean	SD	Mean	SD	
SBP (mmHg)	138.4	13.36	142.04	13.76	0.339
DBP (mmHg)	72.32	10.11	71.04	8.99	0.630
MAP (mmHg)	94.44	8.07	94.70	8.59	0.910
Respiratory rate (breaths/min)	20.64	4.07	20.89	2.36	0.787

In the study, comparison based on vitals in two groups at 1 minute after SBT. It was found that the vitals in both groups at 1 minute after SBT were statistically similar.

Table 4: Comparison based on ABG parameters in two groups at 1 minute after SBT

Parameter	Group A		Group B		P-value
	Mean	SD	Mean	SD	
pH	7.38	0.074	7.40	0.063	0.263
pCO <sub>2</sub>	37.32	4.670	38.07	4.367	0.550
HCO <sub>3</sub>	23.74	2.880	24.33	1.776	0.375
Na <sup>+</sup>	137.84	5.558	139.26	5.474	0.358
K <sup>+</sup>	3.65	0.521	3.57	0.437	0.542
Ca <sup>+</sup>	1.12	0.276	1.04	0.131	0.188
Lactate	1.26	0.442	1.22	0.316	0.697

ABG parameters in two groups at 1 minute after SBT. It was found that the ABG parameters at 1 minute after SBT were statistically insignificant.

Table 5: Comparison based on vitals in two groups at 30 minute after SBT

Parameter	Group A	Group B
SBP (mmHg)	138.92	143.56
DBP (mmHg)	74.88	71.07
MAP (mmHg)	96.23	95.23
Respiratory rate (breaths/min)	23.92	22.33

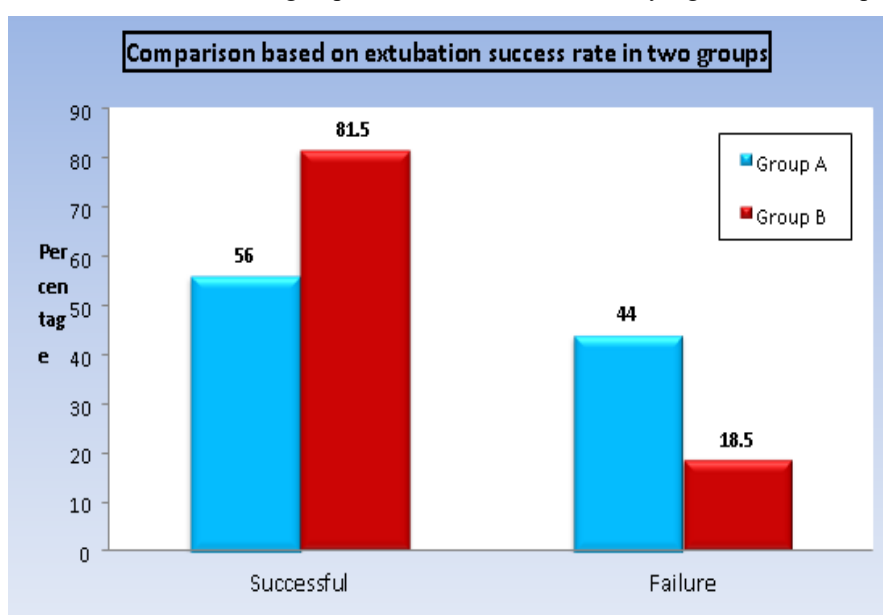
In this present study, comparison based on vitals in two groups at 30 minute after SBT. The difference in vitals between two groups was statistically insignificant.

**Table 6: Comparison based on ABG parameters in two groups at 30 minute after SBT**

Parameter	Group A		Group B		P-value
	Mean	SD	Mean	SD	
pH	7.40	0.166	7.39	0.071	0.706
pCO <sub>2</sub>	36.76	5.615	38.22	4.979	0.324
HCO <sub>3</sub>	23.12	2.804	23.22	2.292	0.890
Na <sup>+</sup>	138.80	4.752	140.70	4.639	0.150
K <sup>+</sup>	3.67	0.454	3.83	0.550	0.267
Ca <sup>+</sup>	1.21	0.443	1.23	0.318	0.878
Lactate	1.28	0.390	1.27	0.345	0.889

Comparison based on ABG parameters in two groups at 30 minute after SBT. The difference in ABG parameters between two groups at 30 minutes was statistically similar.

And, comparison based on extubation success rate in two groups. It was found that 81.5% in group B were extubated successfully whereas only 56% of patients in group A were extubated successfully. The difference in success rates of extubation between two groups was found to be statistically significant with a p value of 0.046.

**Figure 3:****Table 7: ScVO<sub>2</sub> in Group B at 1 minute and 30 minutes in successfully extubated patients**

ScVO <sub>2</sub>	Mean	Range	Change in ScVO <sub>2</sub>	SD	P value
1 Minute	70.6	60-81	2.1	5.04	0.043
30 Minutes	68.5	63-75		2.79	

Study showed that ScVO<sub>2</sub> of successfully extubated patients in group B at 1 minute and 30 minutes. The mean ScVO<sub>2</sub> at 1 minute was 70.6% and at 30 minutes it was 68.5%. The difference in ScVO<sub>2</sub> at 1 and 30 minutes was 2.1% which is statistically significant with a p value of 0.043.

**Table 8: Group B with failed extubation (6 patients)**

Scvo <sub>2</sub>	Mean	Range	Change in Scvo <sub>2</sub>
1 Minute	69	66-71	5.54
30 Minutes	63.16	61-64	

ScVO<sub>2</sub> of patients with failed extubation trial in group B. the mean ScVO<sub>2</sub> at 1 minute was found to be 69 % and at 30 minutes it was 63.16%. The difference in ScVO<sub>2</sub> at 1 and 30 minutes was 5.54%.

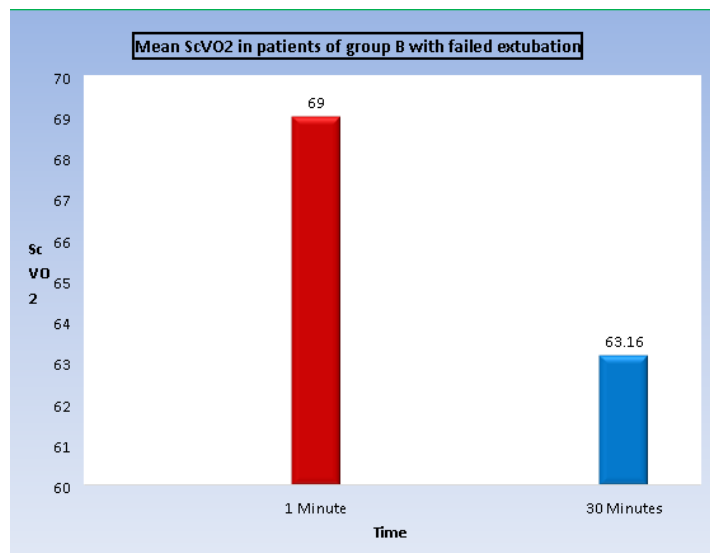


Figure 4:

Table 9: Diagnostic accuracy of central venous oxygen saturation (ScVo<sub>2</sub>) in predicting extubation success

Parameter SCVO <sub>2</sub>	Value (%)	95% CI
Optimal cutoff	≥ 70	
Sensitivity	95.4	78.2-99.1
Specificity	100	56.6-100
PPV	100	84.5-100
NPV	83.3	43.7-96.9
Accuracy	96.3	81.7-99.3
Area under the ROC curve	0.986	0.847-0.998

The diagnostic accuracy of central venous oxygen saturation (ScVo<sub>2</sub>) in predicting extubation success. It was found that ScVO<sub>2</sub> has a sensitivity of 95.4%, specificity of 100%, positive predictive value of 100%, negative predictive value of 83.3% and an accuracy of 96.3% and the graph below shows the area under ROC curve.

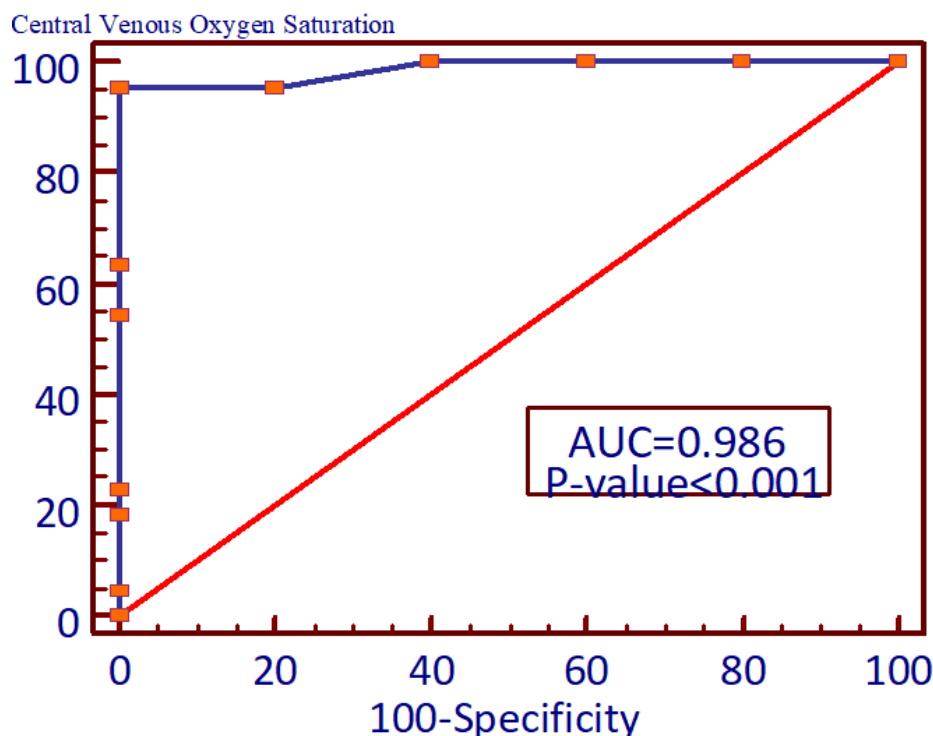


Figure 5:

## Discussions

Tolerating a spontaneous breathing trial may indicate successful weaning, but it does not definitely predict extubation success. After a successful spontaneous breathing trial, the rate of extubation failure within the following 2-3 days may reach up to 30% of the patients. In this prospective, clinical study we established that SCVO<sub>2</sub> as an additional to conventional criteria's can predict the outcome of extubation, with the chance of extubation failure increasing substantially with decrease of SCVO<sub>2</sub> more than 3.8 from its baseline value at the start of SBT.

Corresponding to weaning guidelines, the outcome of SBT depends on a set of different variables and characteristics evaluated upon the termination of the 30 min trial. While measuring SCVO<sub>2</sub> value is not currently considered among these criteria this study establishes the immense role of  $\Delta$ SCVO<sub>2</sub> as an additional factor that has an ability to predict weaning outcome with diagnostic accuracy superior to that of tolerance to SBT alone.

The patients throughout this study were weaned using a two-step protocol, wherein 18.5% of patients had an extubation failure.

In an attempt to understand the effect of cardiac problems on the weaning process an interesting study performed by Jubran A et al[10] demonstrated an elevation in the cardiac index value at the termination of SBT in the successful extubation cluster compared with a non-significant change in the cardiac index value within the failed extubation cluster.

No significant difference was found between the both groups considering different laboratory tests. The same was found with regard to vital signs, wherein there was no difference in both groups at the beginning and at the end of SBT. These results were similar to those of the study carried out by Ayman T and Khalid MIA[11] wherein these reported the absence of any statistically significant variance among both clusters considering clinical features or demographic data (age, sex, in addition to vital signs).

Saugel B et al[12] showed similar results in a cohort study consisting of 61 patients, as they also confirmed the absence of any considerable distinction between patients with successful or failed extubation considering the age, sex, or vital signs, although Savi A et al[13] in a cohort study consisting of 500 patients singled out age a significant variant. This might be explained by the variation in population groups and different reasons for mechanical ventilation addressed in these studies. Our results reported no distinction among both clusters of patients in all central venous blood gases reading at the beginning of 30 minute trial.

However as regard the termination of SBT, patients with successful extubation had significantly higher SCVO<sub>2</sub>, pH, base excess and oxygen saturation compared with a significantly higher pCo<sub>2</sub> in the failed extubation group.

Mokhlesi B et al[14] also found that hypercapnia before extubation significantly increases the chances of weaning failure and is mainly caused by lack of balance between workload and strength of respiratory muscles.

$\Delta$ SCVO<sub>2</sub> was found to be single predictor that predicted failed weaning in addition to the conventional criteria's. Our results showed that the mean difference in SCVO<sub>2</sub> in the group of patients who failed extubation was distinctly more than that of patients with successful extubation, with  $\Delta$ SCVO<sub>2</sub> having high predictive value for extubation failure reaching 91%.

A similar study by Tiexeira et al[15] showed that before SBT the  $\Delta$ SCVO<sub>2</sub> was not different between both groups, but the reduction of SCVO<sub>2</sub> during T-tube trial had the ability to predict extubation failure in 86% of cases, while the SCVO<sub>2</sub> remained unchanged in the extubation success group. According to our study in which 52 patients with different comorbidities were admitted to ICU were studied. Two groups were made, group A and group B among these groups along with the conventional criteria for extubation, the group B was supported with SCVO<sub>2</sub> criteria and it was seen that group B patients had much lower chances of re intubation. Since other parameters did not differ too much among the two groups. The central venous oxygen saturation has significantly improved the successful extubation outcome. As per the statistical analysis the p value holds significance in all parameters.

## Summary

The process of weaning from mechanical ventilator and giving the patient liberty of spontaneous breathing needs a proper clinical evaluation wherein, both subjective and objective criteria need to be met.

In normal physiological settings the central venous oxygen saturation acts as the reservoir which helps to cope with the conditions where the subject has higher demand to supply need till acclimatization. The good reserves help the respiratory muscles to function within norms in usual physiological conditions. When there is fall in Scvo<sub>2</sub> below 60% or more than 4% from the subjects baseline values, the chances of respiratory failure are increased and symptoms like respiratory muscle fatigue and dyspnea become prominent. The return of oxygen in central circulation after the necessary fraction being utilized at tissue level can help to estimate cardiopulmonary reserves of the patient.

We utilized this central oxygen reservoir parameter i.e. Scvo<sub>2</sub> in our study, in which after passing the SBT and 1<sup>st</sup> and 30<sup>th</sup> minutes estimation of conventional criteria and Scvo<sub>2</sub> criteria, patients got extubated and post extubation this reserve has helped them to combat need for higher oxygen requirement by respiratory muscles. Our study concluded that in successfully estimated group of patients tolerating SBT the Scvo<sub>2</sub> at 30 minutes did not fall by or more than 4% of the value at 1<sup>st</sup> minute of SBT. There was a mean difference of 2% fall in Scvo<sub>2</sub> after SBT in our group of patients.

### Conclusions

The present study concluded that the Scvo<sub>2</sub> criteria when added to conventional criteria helps the clinician to estimate proper time for extubation and reduce the rates of reintubation. The previous studies also have revealed that fall in Scvo<sub>2</sub> by more than 4% from baseline values at 30 minutes of SBT have higher chances of extubation failure.

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