Central venous oxygen saturation as the predictor of the outcome from mechanical ventilation

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ABSTRACT

Background: Central venous oxygen saturation is being currently studied and used to guide extubation in patients on ventilator for more than 48 h. **Aims and Objectives:** The aim of our study was to compare chances of extubation failure after mechanical ventilation using conventional versus central venous oxygen saturation criteria for weaning from long-term mechanical ventilation. **Materials and Methods:** This prospective clinical study was conducted in the Postgraduate Department of Anaesthesiology and Critical Care, Government Medical College (GMC) Srinagar and was performed in the Surgical Intensive Care Unit at SMHS, an associated hospital of GMC Srinagar. 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 ScvO2 criteria and conventional criteria combined together. **Results:** Using conventional criteria on 25 patients from 52 patients, 56% had successful weaning while 44% had failure in weaning. Here, 11% should be 44%. While adding ScvO2 criteria on 27 of 52 patients, successful weaning was in 81.48% and failure in 18.52%. With sensitivity of 95.4%, specificity of 100%, positive predictive value of 100%, negative predictive value of 83.3%, and accuracy of 96.3% with confidence interval of 95%. **Conclusion:** ScvO2 criteria when added to conventional criteria help the clinician to estimate proper time for extubation and reduce the rates of reintubation.

Key words: Central venous oxygen saturation; Ventilation, Weaning

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.[1-4]

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.[5,6] The patient should have an adequate gas exchange, appropriate neurological and muscular status, and stable cardiovascular function. Extubation failure (EF)

occurs in approximately 20–32% of the patients meeting the conventional predictors.[7-11] The presence of cardiovascular dysfunction can contribute to weaning failure by increasing loads and decreasing neuromuscular capacity.

Although respiratory muscles do not develop fatigue, they perform huge workload. Thus, they rely on efficient oxygen transport by the cardiovascular system. Central venous oxygen saturation (ScvO2) has been successfully used to determine the outcome from mechanical ventilator.

As such in the weaning process (recovery stage from critical illness), measurement of ScvO2 could potentially be a reliable and convenient tool to warn rapidly about acute changes in the oxygen supply and demand of these patients.

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It has the potential to help the clinician to predict the timely extubation in mechanically ventilated patients. During spontaneous breathing trial (SBT) ScvO2 could predict EF.

The aim of this study was to compare the chances of EF after mechanical ventilation using conventional versus 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.

MATERIALS AND METHODS

This prospective clinical study was conducted in the Postgraduate Department of Anesthesiology and Critical Care, Government Medical College (GMC) Srinagar and was performed in Surgical Intensive Care Unit at SMHS, an associated hospital of GMC Srinagar after approval by the Institutional Ethical Committee. The informed consent was taken from all the patients or next of kin.

A total of 52 patients were taken in this study. They were mechanically ventilated for more than 48 h in surgical ICU at Government Medical College Srinagar and were prospectively followed. They were assessed daily for the presence of the following readiness to wean criteria:

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 min.

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

Sampling of ScvO2 was carried out using catheter threaded through internal jugular vein into the 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 the next 48 h for the presence of any adverse events and respiratory failure.

Failure of extubation was meant that there was a need to re-intubate the patient within 2 days of the extubation process.

Measurements of hemodynamics (blood pressure, heart rate, and respiratory rate) and ScvO2 was registered at 1st min of SBT. Patients were put on T-piece and observed for 30 min and, at 30th min again the conventional criteria and central venous sample was taken.

After observing the patients during the 30-min period and re-checking 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 non-invasive 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 min. Patients were observed for 48 h 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-h period as per ICU protocol.

Statistical analysis

To perform different analysis within the study we used version 22.0 of the statistical package for the social sciences (SPSS) for windows (SPSS Inc., Chicago, Illinois USA). Descriptive data are demonstrated as percentage or mean $\pm$ SD. χ^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. For all tests, any probability value (<0.05) was described as the statistically significant. Same t of study has been done before by Samiha S Ashmawi et al.,[12] which included 50 patients with the aim of central venous oxygen saturation as a predictor of failure of weaning from mechanical ventilation.
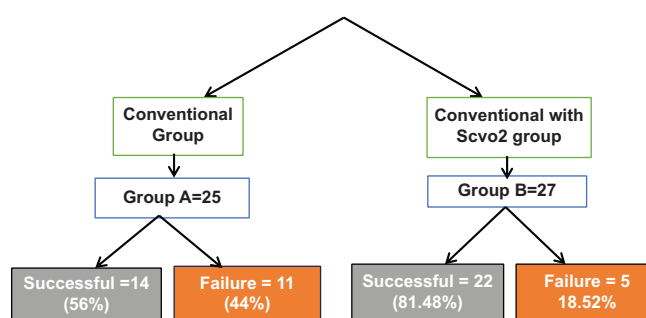
Here in Group B failure box 18.52% should be within bracket. Like Failure = 5 (18.52%)

RESULTS

In our study, we evaluated 52 patients who were mechanically ventilated for more than 48 h and compared

EF in these patients using conventional verses central venous oxygen saturation criteria for weaning from mechanical ventilation. Demographic parameters such as age and gender were compared between two groups and found statistically insignificant (P<0.05) as shown in Tables 1 and 2.

Table 1 shows 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 shows the gender distribution of patients in groups A and B.The difference between the two groups was found to be statistically insignificant.

The difference in ventilation days between two groups was found to be statistically insignificant (P<0.05) as shown in Table 3.

The difference in hemodynamic parameters and respiratory rate between the two groups was found statistically insignificant as depicted in Table 4.

The difference in ABG parameters between the two groups at I min time after SBT was found to be statistically insignificant as shown in Table 5.

The difference in hemodynamic parameters between the two groups at 30 min after SBT was found to be statistically insignificant as depicted in Table 6.

The difference in ABG parameters between the two groups at 30 min time after SBT was found to be statistically insignificant as shown in Table 7.

Table 8 shows group B has 81.5% successful extubation as compared to group A (56%) and the difference between the two groups was statistically significant (P<0.05).

The mean Scvo2 at 1 min was 70.6% and at 30 min was 68.5% and the difference in Scvo2 at 1 min and 30 min was 2.1% which is statistically significant (P=0.043) as shown in Table 9a.

The difference in Scvo2 at 1 min and 30 min between the two groups is 5.54% which is statistically insignificant (P=5.54) as depicted in Table 9b.

Table 10 shows central venous oxygen saturation has a sensitivity of 95.4%, specificity of 100%, positive predictive value of 100%, negative predictive value of 83.3%, and diagnostic accuracy of 96.3%.

DISCUSSION

Tolerating a SBT may indicate successful weaning, but it does not definitely predict extubation success. After

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)		

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	

Table 3: Ventilator duration (days) of study patients in two groups

Group	N	Mean	SD	Range	P-value
Group A	25	3.9	1.013	3–7	0.564
Group B	27	4.1	1.357	3–8	

Table 4: Comparison based on vitals in two groups at 1 min 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

SBT: Spontaneous breathing trial

Table 5: Comparison based on ABG parameters in two groups at 1 min 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$_2$	37.32	4.670	38.07	4.367	0.550
HCO$_3$	23.74	2.880	24.33	1.776	0.375
Na+	137.84	5.558	139.26	5.474	0.358
K+	3.65	0.521	3.57	0.437	0.542
Ca+	1.12	0.276	1.04	0.131	0.188
Lactate	1.26	0.442	1.22	0.316	0.697

SBT: Spontaneous breathing trial

Table 6: Comparison based on vitals in two groups at 30 min 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

SBT: Spontaneous breathing trial

Table 7: Comparison based on ABG parameters in two groups at 30 min 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_2	36.76	5.615	38.22	4.979	0.324
HCO_3	23.12	2.804	23.22	2.292	0.890
Na+	138.80	4.752	140.70	4.639	0.150
K+	3.67	0.454	3.83	0.550	0.267
Ca+	1.21	0.443	1.23	0.318	0.878
Lactate	1.28	0.390	1.27	0.345	0.889

SBT: Spontaneous breathing trial

Table 8: Comparison based on extubation success rate in two groups

Extubation	Group A		Group B		P-value
	No.	%age	No.	%age	
Successful	14	56	22	81.5	0.046*
Failure	11	44	5	18.5	
Total	25	100	27	100	

Table 9a: ScvO2 in Group B at 1 min and 30 min in successfully extubated patients

ScvO2	Mean	Range	Change in ScvO2	SD	P value
1 Min	70.6	60–81	2.1	5.04	0.043
30 Min	68.5	63–75		2.79	

ScvO2: Central venous oxygen saturation

Table 9b: Group B with failed extubation (6 patients)

ScvO2	Mean	Range	Change in ScvO2
1 Min	69	66–71	5.54
30 Min	63.16	61–64	

ScvO2: Central venous oxygen saturation

Table 10: Diagnostic accuracy of ScvO2 in predicting extubation success

Parameter ScvO2	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

ScvO2: Central venous oxygen saturation
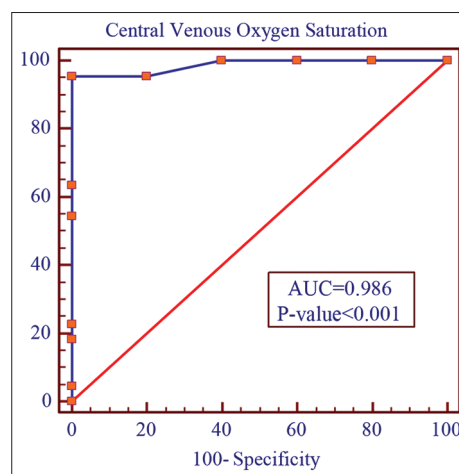
Corresponding to weaning guidelines, the outcome of SBT depends on a set of different variables and characteristics evaluated upon the termination of the 30 min trial. While measuring ScvO2 value is not currently considered among these criteria this study establishes the immense role of ΔScvO2 as an 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. Cason CL et al. [13] indicated that SCVO2 was an important predictor of weaning failure, since weaning failure was associated with a drop SCVO2 of over 60%. ΔSCVO2 was found to be single predictor that predicted failed weaning in additional to the conventional criteria. Our results showed that the mean difference in SCVO2 in the group of patients who failed extubation was distinctly more than that of patients with successful extubation with ΔSCVO2 having high predictive value for extubation failure reaching 91%.

In an attempt to understand the effect of cardiac problems on the weaning process an interesting study performed by Jubran A et al.,[14] demonstrated an elevation in the cardiac index value at the termination of SBT in the successful extubation cluster compared with a nonsignificant change

a successful SBT, the rate of EF within the following 2–3 days may reach up to 30% of the patients.

In this prospective, clinical study we established that ScvO2 as an additional to conventional criteria's can predict the outcome of extubation, with the chance of EF increasing substantially with decrease of ScvO2 more than 3.8 from its baseline value at the start of SBT.

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 MI[15] 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.,[16] 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.,[17] 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-min trial. However, as regard the termination of SBT, patients with successful extubation had significantly higher ScvO2, pH, base excess, and oxygen saturation compared with a significantly higher pCo_2 in the failed extubation group.

Mokhlesi B et al.,[18] 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.

ΔScvO2 was found to be single predictor that predicted failed weaning in additional to the conventional criteria. Our results showed that the mean difference in ScvO2 in the group of patients who failed extubation was distinctly more than that of patients with successful extubation, with ΔScvO2 having high predictive value for EF reaching 91%.

A similar study by Tiexeira C et al.,[4] showed that before SBT the ΔScvO2 was not different between both groups, but the reduction of ScvO2 during T-tube trial had the ability to predict EF in 86% of cases, while the ScvO2 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 ScvO2 criteria and it was seen that group B patients had much lower chances of reintubation. 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.

In the previous studies Jubran A et al.,[14] (1998) utilized Svo2, monitoring in order to assess cardiovascular performance and global tissue oxygenation during the weaning process. In this study the group of patients who failed weaning established a progressive decrease in ScvO2 values, compared to the rest, probably reflecting the increased O2ER of respiratory muscles.

Limitations of the study
None.

CONCLUSION

Our study concluded that in successfully extubated group of patients tolerating SBT, the ScvO2 at 30 min did not fall by more than 4% of the value at 1st min of SBT. There was a mean difference of 2% fall in ScvO2 after SBT in our group of patients. So, we concluded that the ScvO2 criteria when added to conventional criteria help 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 min of SBT have higher chances of extubation failure.

ACKNOWLEDGMENT

REFERENCES

1. Asteban A, Ferguson ND, Maedemo, Frusto-Vivar F, Apezteguia C, Bocharc L, et al. Evolitoom of mechanical ventilation I response to clinical research. Am J Respir Crit Care Med. 2008; 177(2): 170-177. https://doi.org/10.1164/rccm.200706-893OC

2. Boles JM, Bion J, Connors A, Herridg M, Marsh B, Melot C, et al. weaning from mechanical ventilation. Eur Respir J. 2007;29(5):1033-1056.

   https://doi.org/10.1183/09031936.00010206

3. Macintyre NR, Cook DJ, Ely EW Jr., Epstein SK, Fink JB, Heffner JE, et al. Evidence-based guidelines for weaning and discontinuing ventilatory support: A collective task force facilitated by the American college of chest physicians; the American association for respiratory care; and the American college of critical care medicine. Chest. 2001;120(6):3755-3955. https://doi.org/10.1378/chest.120.6_suppl.375S

4. Teixeira C, D Silva NB, Savi et al. Central venous saturation is a predictor of reintubation in difficult-to-wean patients. Critical Care Med. 2010;38(2):491-496.

   https://doi.org/10.1097/CCM.0b013e3181bc81ec

5. Estaban A, Frutos F, Tobin MJ, Alía I, Solsona JF, Valverdú I, Fernández R, et al. A comparison of four methods of weaning patients from mechanical ventilation. Spanish lung failure collaborative group. N Engl J Med. 1995;332(6):345-350.

    https://doi.org/10.1056/NEJM199502093320601

6. Torres A, Serra-Batlles J, Ros E, Piera C, de la Bellacasa JP, Cobos A, et al. Pulmonary aspiration of gastric contents in patients receiving mechanical ventilation: The effect of body position. Ann Intern Med. 1992;116(7):540-543.

    https://doi.org/10.7326/0003-4819-116-7-540

7. Estaban A, Alia I, Tobin MJ, Gil A, Gordo F, Vallverdú I, et al. Effect of spontaneous breathing trial duration on outcome of attempts to discontinue mechanical ventilation. Spanish Lung Failure Collaborative Group. Am J Respir Crit Care Med. 1999;159(2):512-518. https://doi.org/10.1164/ajrccm.159.2.9803106

8. Vallverdo I, Calef N, Subirana M, Net A, Benito S and Mancebo J. Clinical characteristics, respiratory functional parameters, and outcome of a two-hour T-piece trial in patients weaning from mechanical ventilation. Am J Respir Crit Care Med1998;158(6):1855-1862. https://doi.org/10.1164/ajrccm.158.6.9712135

9. Lee KH, Hui KP, Chan TB, Tan WC and Lim TK. Rapid shallow breathing (frequency-tidal volume ratio) did not predict extubation outcome. Chest. 1994;105(2):540-543.

    https://doi.org/10.1378/chest.105.2.540

10. Meady MO, Guyatt G, Cook D, Griffith L, Sinuff T, Kergl C, et al. Predicting success in weaning from mechanical ventilation. Chest. 2001;120 Suppl 6:400s-424s.

    https://doi.org/10.1378/chest.120.6_suppl.400S

11. Conti G, Montini L, Penniksi MA, Cavaliere F, Arcangeli A, Bocci MG, et al. A prospective, blinded evaluation of indexes proposed to predict weaning from mechanical ventilation. Intensive Care Med. 2004;30(5):830-838.

    https://doi.org/10.1007/s00134-004-2230-8.

12. Samiha S. Ashmawi, Hala M. Salem, Muhammad E. Nagy. Central venous oxygen saturation as a predictor of failure of weaning from mechanical ventilation. Egyptian J of Chest Diseases and Tuberculosis. 2020; 69: 155-161.

13. Cason CL, DeSalvo SK and Ray WT. Changes in oxygen saturation during weaning from short-term ventilator support after coronary artery bypass graft surgery. Heart Lung. 1994;23(5):368-375.

14. Jubran A, Mathru M, Dries D and Tobin MJ. Continuous recordings of mixed venous oxygen saturation during weaning from mechanical ventilation and the ramifications thereof. Am J Respir Crit Care Med. 1998;158(6):1763-1769.

    https://doi.org/10.1164/ajrccm.158.6.9804056

15. Ayman T and Khalid MI. Central venous oxygen saturation as a predictor of extubation failure in mechanically ventilated chronic obstructive pulmonary disease patients. J Am Sci. 2014;10:6.

16. Saugel B, Rakett P, Hapfelneier A, Schulthesis C, Phillip B, Thies P, et al. Prediction of extubation failure in medical intensive care unit patients. J Crit Care. 2012;27(6):571-577. https://doi.org/10.1016/j.jcrc.2012.01.010

17. Savi A, Teixeira C, Silva JM, Borges LG, Pereira PA, Pinto KB, et al. Weaning predictors do not predict extubation failure in simple-to-wean patients. J Crit Care. 2012;27(2):221.e1-221.e8. https://doi.org/10.1016/j.jcrc.2011.07.079

18. Mokhlesi B, Tulaimat A, Gluckman TJ, Wang Y, Evans AT and Corbridge TC. Predicting extubation failure after successful completion of a spontaneous breathing trial. Respir Care. 2007;52(12):1710-1717.