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Influence of Arterial Blood Gas to Guide Extubation in Intensive Care Unit Patients after Spontaneous Breathing Trial

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ABSTRACT

Background: Arterial blood gas is required for extubation decision after spontaneous breathing trial in most of intensive care unit. This study was conducted to assess the influence of arterial blood gas for extubation after successful spontaneous breathing trial in intensive care unit patients planned for extubation.

Methods: It was prospective observation study conducted in all patients of age greater than eighteen year admitted in intensive care unit of tertiary care hospital for one year. It was done in 108 patients who were planned for extubation. Patients were assessed by intensivist clinically and decided whether a patient can be extubated on clinical grounds. Spontaneous breathing trial was done for 2 hours by t-piece in patients who met clinical and objective criteria. Arterial blood gas was done in all patients who successfully completed spontaneous breathing trial. Patients with successful spontaneous breathing trial, acceptable arterial blood gas were extubated. Independent Student's t test and paired t test was used for data analysis.

Results: Out of 108 patients who passed the spontaneous breathing trial, 96(88.88%) patients had acceptable arterial blood gas and were extubated and 12(11.11%) patients did not have acceptable arterial blood gas level and were chosen to have other mode of weaning.

Conclusions: This study demonstrates that arterial blood gas level has changed decision for extubation after successful spontaneous breathing trial. Further, arterial blood gas might help in identification of patients who can undergo extubation failure when rapid shallow breathing index failed to predict outcome of extubation.

Keywords: Arterial blood gas; extubation; spontaneous breathing trial; weaning

INTRODUCTION

The process of weaning from the ventilator begins with assessment for weaning readiness and spontaneous breathing trial (SBT).[1] Spontaneous breathing trials (SBTs) quickly identifies the capacity of unassisted breathing. Arterial blood gas (ABG) level used in most ICUs to guide extubation after successful SBT was found more accurate than peak negative pressure and vital capacity for predicting sustainability of adequate spontaneous respiration [2] and is safest method of monitoring weaning process.[3] The ABGs results caused physician to defer extubation in patients judged otherwise to have passed the SBT in several instances.[4]

There is lack of evidence and uniformity in use of ABG level in different studies during weaning process after successful SBT. This study was performed to assess the influence of ABG for extubation after successful SBT in ICU patients under mechanical ventilation planned to undergo extubation. The secondary objective was to correlate clinical parameters and ABG decision for extubation and to correlate rapid shallow breathing index (RSBI) with successful extubation.

METHODS

We conducted a prospective observational study in an eleven bedded tertiary level mix surgical medical ICU for one year. Ethical approval from Institutional Review Board was obtained before enrollment of patients in this study. Written informed consent was obtained from

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surrogate decision maker of patient.

All patients > 18 year admitted in ICU of tertiary level hospital who underwent Invasive Mechanical Ventilation and were planned to undergo extubation were included in this study. Patient whose surrogate decision maker did not give written informed consent were excluded from this study.

Ventilator management was done as per protocol of ICU and decision of treating physician. Intensivist thoroughly assessed the patient clinically and decided whether a patient could be extubated on clinical grounds. We collected the following data from each patient age, sex, sequential organ failure assessment (SOFA) score, reason for intubation, number of days on mechanical ventilation, mode of mechanical ventilation, and hemoglobin on the day of planned extubation. Heart rate(HR), systolic blood pressure(SBP), diastolic blood pressure(DBP), mean arterial pressure(MAP), respiratory frequency, and oxygen saturation as measured by oximetry (SpO_2) while on the ventilator and during the SBT pH, partial pressure of oxygen(PaO_2), partial pressure of carbon dioxide($PaCO_2$), partial pressure of oxygen/ fraction of inspired oxygen ratio(PaO_2/FiO_2) values on full ventilatory support prior to and after the SBT.

The decision to start SBT by t-piece for 2 hours was made by Intensivist once the patient meets all of the following clinical and objective criteria as (i) clinical assessment: (a) presence of cough reflex on tracheal suctioning. (b) absence of excessive secretion (ii) objective measurement: (a) MAP>65mm of Hg with no or low dose Vasopressors such as dopamine or dobutamine 5mcg/kg/min or nor adrenaline 0.05mcg/kg/min (b) GCS>8 (verbal component is excluded in intubated patient) eye and motor component will be only included (c) No fever(Temperature<38^{0}C)(d) heart rate<140/min (e) spontaneous tidal volume(V_T) >5 ml/kg (f) spontaneous frequency(f)<35/min(g) f/V_T<105(h) minute ventilation<10 liter (i)SpO_2>90 on FiO_2<0.4.

RSBI was calculated by setting PEEP=0 and PSV=0 cm H_20 for 1 minute before patient was started on T-piece trial. Tidal volume and RR was displayed on ventilator. RSBI was calculated as the ratio of tidal volume and RR.

During SBT if patient manifest any one of the following sign for 2 minute then, it was considered as SBT failure (a)SaO_2<90 on FiO_2>50% (b) f>35/min or increase by >50% from baseline of SBT (c) HR>140/min or increase by >20% from baseline of SBT (d) SBP>180 mm Hg or increase by>20% from baseline of SBT (e) SBP<90 mm Hg (f) Presence of cardiac arrhythmias (g) Cyanosis (h) Diaphoresis. After successful completion of SBT, ABG level was done.

Patient was extubated who had met the acceptable ABG criteria as follows: (a) $_pH$=7.35-7.45 (b) $PaCO_2$<50 mm Hg (c) PaO_2 without PEEP >60 mm of Hg (d) PaO_2/FiO_2>150.

Patient with successful SBT, but unacceptable ABG were not extubated and were managed according to intensivist on duty. Patient was observed for 48 hours for extubation failure.

Sample size was calculated by formula $Z^2pq/d^{2.}$. Z is 1.96 at 95%, p is reference, q is 100-p and d is allowable error. Considering allowable error 5%, dropout rate of 10% and 80% power of study sample size was 108. Convenience sampling method was used. Bias was reduced by collecting data from all groups of patients until sample size was achieved. Valididity and reliability of ventilator and monitor was assured to avoid data collection bias. Data collection was done in a preformed sheet. Preformed sheet included all physiologic variables and demographic variables. All data was transferred to excel sheet and then transferred to SPSS-17.Values are presented as mean (±standard deviation SD) or frequency. Independent Student's t test was used to compare mean values of hemodynamic, respiratory and ABG variables between patients who were extubated and not extubated after ABG result. Paired t test was used to compare mean values of physiologic variables among patients who did not have acceptable ABG level for extubation. For all determination p-value<0.05 was considered statistically significant.

RESULTS

One hundred and eight patients were included in the study. Surrogate decision maker did not give consent because they did not want to participate in study. Other patients were excluded due to exclusion criteria. Patient that were not included may cause selection bias.

Table 1. Demographics and clinical characteristics of study population.

Parameters	
Age Mean±SD,Years	45.85±19.63
Sex Male/Female,n	56/52
Diagnosis at time of admission	
Neurological n(%)	53(49.1)
Pneumonia n(%)	18(16.7)
Gastrointestinal n(%)	11(10.2)

Chronic obstructive airway disease n(%)	10(9.3)
Infectious disease n(%)	6(5.6)
Renal disease n(%)	5(4.6)
Multiple trauma n(%)	5(4.6)
SOFA score at time of admission	
>11 n(%)	26(24.7)
8-11 n(%)	58(53.7)
2-7 n(%)	24(22.22)
Comorbidities	
Hypertension n(%)	22(20.4)
Diabetes mellitus n(%)	16(14.8)
Chronic kidney disease n(%)	11(10.2)
Chronic obstructive airway disease n(%)	10(9.3)
Other respiratory disease n(%)	7(6.5)
Liver disease n(%)	2(1.9)

The mean age was 45.85±19.63 years, 56(51.9%) were female and 52(48.1%) were male. Most of the patient in the study was having neurological disease and high SOFA score at time of admission in ICU. Hypertension was most common co morbidity in our study population.

Table 2. Patient who have acceptable ABG and non acceptable ABG after SBT.

Spontaneous breathing trial, N=108	
Acceptable ABG n(%)	96(88.88%)
Successful Extubation n(%)	85(88%)
Unsuccessful Extubation n(%)	11(12%)
Non acceptable ABG n(%)	12(11.11%)
Successful Extubation to BiPAP n(%)	5(41.66%)
Tracheostomy n(%)	7(58.335)

Table 3. Comparing the characteristics of Extubated and Not Extubated group of patients after successful spontaneous breathing trial.

Characteristics	Mean±SD (Extubated) n=96	Mean±SD (Not Extubated) n=12	p value
Mechanical Ventilation (Days)	3.96±2.94	5.67±4.6	0.079
Respiratory Parameters before Spontaneous Breathing Trial			
Respiratory Rate (/min)	18.49±3.76	19.67±2.93	0.299
Tidal Volume(ml)	386.26±37.87	382.67±40.99	0.759
Rapid Shallow Breathing index(breaths/min/l)	54.69±16.66	60.75±16.61	0.237
Minute Volume(L/min)	7.13±1.54	7.72±1.30	0.206
SpO_2 (%)	96.51±2.13	95.08±2.75	0.036
FiO_2 (%)	40±.0	40±.0	
ABG Parameters before Spontaneous Breathing Trial			
$_pH$	7.40±.05	7.38±.05	0.264
PaO_2 (mm Hg)	80.96±10.93	86.33±13.99	0.123
$PaCO_2$ (mm Hg)	37.95±3.01	39.17±3.66	0.200
PaO_2/FiO_2	201.91±27.17	215.83±34.97	0.108
SaO_2 (%)	95.74±2.19	95.33±1.61	0.536
Respiratory Parameters during Spontaneous Breathing Trial			
Respiratory Rate (/min)	23.20±4.84	24.67±2.61	0.306
SpO_2 (%)	96.16±2.29	96.50±1.88	0.619
ABG Parameters after Spontaneous Breathing Trial			
$_pH$	7.39±0.04	7.39±0.12	0.687
PaO_2 (mm Hg)	78.85±10.70	68.25±19.24	0.004
$PaCO_2$ (mm Hg)	38.64±3.34	43.57±14.80	0.006
PaO_2/FiO_2	197.13±27.24	170.79±47.89	0.005
SaO_2 (%)	95.24±2.31	94.75±4.80	0.500

Out of 108 patients who passed the SBT, 96(88.88%) patients had acceptable ABG level and were extubated. 12(11.11%) patients did not have acceptable ABG level and were chosen to have other mode of weaning. Out of 12 patients 5(41.66%) underwent successful extubation to Bilevel positive airway pressure (BiPAP) and 7(58.33%) underwent tracheostomy.

Eleven patients had extubation failure. Out of 11 patients 5(45.4%) underwent successful to BiPAP, 2 (18.18%) underwent tracheostomy and 3 (27.27%) expired.

Table 3 compares the characteristics of extubated and non extubated group of patients after successful spontaneous breathing trial and ABG. Mean PaO_2 of 68.25±19.24, mean $PaCO_2$ of 43.57±14.80, mean PaO_2/FiO_2 170.79±47.89 were statistically significant ($p<0.05$) to cause change in decision for extubation after successful SBT.

Table 4 represents result of ABG of 12 patients who were not extubated after successful SBT and unacceptable ABG.

Table 5 shows change in physiological variables among patients who did not have acceptable ABG for extubation. Out of 108 patients included in the study, 12 patients were not extubated after an unacceptable ABG. There was a change in mean heart rate of 117.33±12.87/min before SBT to 130.33±12.77/min during SBT, respiratory rate of 19.67±2.93/min before SBT to 24.67±2.61/min during SBT and mean arterial pressure of 100.25±9.31mm of Hg during SBT to 93.78±10.05 mm of Hg in those 12 patients. All above mentioned changes were statistically significant ($p<0.05$) to cause change in decision for extubation after successful SBT.

Table 4. Result of ABG analysis of 12 patients who were not extubated after successful spontaneous breathing trial.

No	pH	PaO_2 (mm mg)	$PaCO_2$ (mm Hg)	PaO_2/FiO_2	SaO_2 (%)
1	7.55	79	25.8	197.5	97
2	7.29	70	65	175	92
3	7.38	56	38	140	90
4	7.35	55	41	138	90
5	7.56	86	29	215	96
6	7.31	55	36	138	90
7	7.3	61	65	152	92
8	7.24	112	67	280	96
9	7.37	56	39	137	90
10	7.34	51	36	132	89
11	7.34	50	51	125	89
12	7.6	88	30	220	95

Table 5. Change in physiologic variables among patients who did not have acceptable ABG for extubation

Characteristics	Before Spontaneous Breathing Trial Mean±SD n=12	During Spontaneous Breathing Trial Mean±SD n=12	P value
Heart rate(/min)	117.33±12.87	130.33±12.77	0.002
Respiratory rate(/min)	19.67±2.93	24.67±2.61	<0.001
Mean Arterial Pressure(mm Hg)	100.25±9.31	93.78±10.05	0.002

Table 6. Shows Rapid shallow breathing index for successful extubation and unsuccessful extubation.

Characteristics RSBI	Successful Extubation Mean±SD	Unsuccessful Extubation Mean±SD	P value	Sensitivity	Specificity	PPV	NPV
	55±17.05	52.24±13.71	0.60	54.55%	43.53%	11.11%	88.10%

Table 6 shows rapid shallow breathing index for successful extubation and unsuccessful extubation along with other attributes. The mean RSBI for successful extubation was 55±17.05 and unsuccessful extubation was 52.24±13.71 and was not statistically significant (p=0.607); 48.5 was cutoff value for successful and unsuccessful extubation. Sensitivity 54.55%, specificity 43.53%, positive predictive value (PPV) 11.11% and negative predictive value (NPV) was 88.10%.

Ninety six patients who were extubated 85(88%) underwent successful extubation and 11(12%) underwent unsuccessful extubation.

Eleven patients had extubation failure. Out of 11 patients 5(45.4%) underwent successful to BiPAP, 2 (18.18%) underwent tracheostomy and 3 (27.27%) expired.

Twelve patients(12%) were not extubated and 5(41.66%) underwent successful extubation to BiPAP and 7(58.33%) underwent tracheostomy.

DISCUSSION

Successful SBT demonstrates acceptable oxygenation and ventilation for extubation. ABG analysis remains the acceptable standard for evaluating gas exchange and ABG samples are drawn at the end of successful SBT to confirm bedside clinical parameters for ventilation and oxygenation in most of ICU.[5] However, there is a great challenge in the availability of ABG analysis in a developing country. Hence, research was done to know whether clinical parameters changes decision for extubation once the patients successfully passes SBT.

In this present study, ABG result did not change extubation decision in 96 (88.88%) of patients which is similar to other studies in which percentage varied from 93% to 94 %.[4,6]

In this present study, ABG result changed decision to extubate in 12% patients while in other studies,[4,7,8] percentage varied from 7% to 100%.This difference may be due small sample size in other studies.

Study conducted by Salam et al [4] showed that change in heart rate, respiratory rate was significant for change in decision to extubate which is similar to our study.

The present study shows that 12% patient had extubation failure. It shows that results of ABG analysis has helped to decrease the potential extubation failure from 20% to 12% as 108 patients would have been extubated as 108 patients has passed clinical parameters for extubation but ABG analysis helped to identify 12 patients that underwent other mode of extubation like BiPAP and tracheostomy.

In this study sensitivity, specificity, PPV and NPV of RSBI was 54.55%.43.53%, 11.11% and 88.10% respectively. This result is similar to other studies [9,10] which also showed that RSBI fails to predict extubation outcome. So, ABG might help in identification of patients who could undergo unsuccessful extubation when RSBI fail to predict extubation outcome.

This study showed that ABG changed intensivist's decision for extubation and may help in identification of patients who could have extubation failure.Randomization of sampling was not done and there was no comparison group that may cause selection bias. There was no intention to treat analysis that may cause analysis bias. There are limited studies on ABG after SBT, small sample size, single center, single method of weaning and non randomization of sample may affect the application of results

CONCLUSIONS

Arterial blood gas result is useful for extubation decision after a successful spontaneous breathing trial. Rapid shallow breathing index was found to have a poor predictive value for identifying extubation success. In such cases, arterial blood gas result may help in identification of patients who may fail extubation despite a successful rapid shallow breathing index.

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