

Validation of two preoxygenation techniques, 3 min tidal volume breath and eight vital capacity breath techniques in tribal and non-tribal population of Eastern India



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ABSTRACT

Background: Preoxygenation during anesthesia can be done by 3 min tidal volume breath and eight vital capacity breath in 1 min, conventionally. Population of our country is not homogenous. **Aims and Objectives:** The present study was conducted to validate preoxygenation processes in people of eastern India. **Materials and Methods:** Total 140 patients of ASA grade I and II, age group 20–50 posted for surgeries under GA were allotted in TV and VC group. Every odd number and even number patient was tested for TV method and VC method, respectively, with a Magill circuit and airtight face mask with 100% oxygen flow at a rate of 10 L/min. Time and number of breaths were noted when end tidal oxygen concentration $\geq 90\%$ in TV and VC group, respectively. **Results:** In TV method, the mean time (in minute) was 3.10 ± 0.27 and 3.13 ± 0.24 for tribal and non-tribal sub-group ($P=0.80$); 3.02 ± 0.37 and 3.10 ± 0.27 for tribal and non-tribal male ($P=0.57$); and 3.18 ± 0.05 and 3.16 ± 0.21 for tribal and non-tribal female ($P=0.57$). In VC method, mean number of VC breaths was 8.32 ± 0.60 and 8.43 ± 0.74 for tribal and non-tribal sub-group ($P=0.76$); 8.75 ± 0.49 and 8.23 ± 0.70 for tribal and non-tribal male ($P=0.42$); and 8.20 ± 0.60 and 8.60 ± 0.72 for tribal and non-tribal female ($P=0.16$). Patients completing preoxygenation in TV and VC method – tribal: 22% and 53%, non-tribal: 4% and 62%, tribal male: 22% and 20%, non-tribal male: 8% and 68%, tribal female: 0% and 60%, and non-tribal female: 0 and 57%, respectively. **Conclusion:** No significant difference found between tribal and non-tribal groups of both sexes in each method. Completion of preoxygenation was higher in VC group, though not tested statistically.

Key words: Preoxygenation; Tidal volume; Vital capacity; Tribal; Non-tribal

INTRODUCTION

Preoxygenation, also known as denitrogenation, is a common safety measure in anaesthesiology as a conventional practice. This has a significant impact on body oxygen store and increases tolerance to apnea substantially. Preoxygenation is considered completed when end tidal oxygen concentration (EtO_2) is more than 90%.¹

Preoxygenation can be done by two methods, tidal volume breath (TVB), and vital capacity breath (VCB).

All India Difficult Airway Association (AIDAA), in 2016, recommended guideline for optimal preoxygenation. According to this, preoxygenation should be done for a minimum of 3 min of TVB or 8 VCB in 60 s with 100% O_2 at a fresh gas flow (FGF) rate of 10 L/min (L/min), when no mask leak is present. End point of preoxygenation is EtO_2 more or equal to 90% and end tidal nitrogen (EtN_2) $< 4\%$.²

Factors that have effect on preoxygenation and arterial saturation are age, build, gender, ethnicity, positioning,

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environmental factors, geographical location, occupation, metabolic rate, hemoglobin concentration, functional residual capacity, state of the airway (closed vs. open), physiological shunt and dead space, obesity, pregnancy, critical illness, head injury, neuromuscular paralysis, etc.³⁻⁶

India has a large diversity of population. This is influenced by different genetic pattern and geographical or regional factors. Hence, different subsection of our population may behave differently to the conventional preoxygenation process. In some subsection, the process may not complete the preoxygenation (achieving target EtO₂) and, in some subsection, the process may get completed before the guided time frame. While going through the literatures no specific data of preoxygenation in the population residing in eastern part of India is available. There is also no data available which are specific to different ethnicity. Even national guideline was formed from the consensus of expert committee, not based on any study.² The aim of this study was to check the appropriateness of 3 min TVB and eight VCB in 1 min technique in patients residing eastern part of India. Patients attending our hospital represent both tribal (T) and non-tribal (NT) population of eastern India as it receives patients from different parts of West Bengal and Jharkhand. Hence, appropriateness of conventional methods and any difference in the behavior of preoxygenation among T and NT population was also checked in this study.

Aims and objectives

Aim of this study was to measure the time to reach 90% EtO₂ in TV method and number of vital capacity breaths to reach 90% EtO₂ in VC method, in tribal and non-tribal population of both sexes of eastern part of India. This study was conducted also to compare and analyze the values among tribal and non-tribal population of both genders of eastern India.

MATERIALS AND METHODS

This study was conducted in a tertiary care hospital and medical college. Patients attending pre-anesthetic checkup (PAC) clinic with ASA grade I and II, 20–50 years of age from both T and NT population who were posted for elective general and gynecological surgeries under general anesthesia (GA) were selected as the study subjects. Patients with anticipated difficult intubation, obese patients (BMI >30 kg/m²), smokers, patients with history of alcohol or drug abuse, pregnant and lactating patients, history of pulmonary, and musculoskeletal diseases affecting chest and patients having controversy regarding ethnicity were excluded from the study. Patients only who demanded themselves as tribal on asking and could show caste

certificate issued by Government body confirming as scheduled tribe, were considered as T sub-group of study subjects. Rest of the patients were included into NT sub-group. All eligible patients were selected for this study and the selection process continued for 12 months. Selected patients were explained about the study procedure and involved risks and written consent was obtained in their own vernacular language.

Selected patients were enrolled serially as were scheduled for surgery. Every odd number patient, for example, patient no. 1, 3, and 5 were included in TV group and were tested for TVB technique. Every even number patient, for example, patient no. 2, 4, and 6 were included in VC group and were tested for VCB method.

On the day of surgery, before entering the operating room (OR), age, height, and weight of the patient were recorded in the pre-operative room. TVB technique was described, demonstrated, and trained to every odd number patient individually. They were asked to take normal inspiration and expiration as they usually do when a face mask was held on their face air tightly. Patients were asked to perform TVB and were checked if they were doing that correctly. VCB technique was described, demonstrated, and trained to every even number patient individually. They were trained to start with a deepest possible expiration, as much as they could do. Then, a face mask was held air tightly and asked to start taking deepest possible inspiration, as much as they can do. After that, they continued the expiration and inspiration cycle. Speed of respiration was such that eight respirations were completed within 1 min and the participants were asked to continue the vital capacity until they were asked to discontinue. Patients were asked to perform the same and were checked if they were doing that correctly. After completion of demonstration and training of TVB and VCB to patients of TV group and VC group respectively, patients were taken to OR.

In TV group, the patient lied supine on OR table. 100% O₂ was delivered to them with the help of a Magill circuit with a side stream gas analyzer from GE anesthesia Carestation. The gas analyzer gave recording of EtO₂, end tidal carbon dioxide (EtCO₂), and EtN₂. Oxygen flow was kept at a rate of 10 L/min. Mask was held with proper seal to avoid any leak of oxygen. Patients were asked to take TVBs. When preoxygenation was initiated, the stopwatch in monitor of Carestation machine was started. EtO₂ recording was monitored. When preoxygenation point was reached, that is, by EtO₂ becoming 90%, the clock in the monitor was stopped and the time was noted. Excluding preoxygenation, rest of the anesthetic procedure was conducted as per regular standard practice.

In VC group, face mask was held in supine position after the first deepest expiration with a Magill circuit along with a side stream gas analyses from GE anesthesia Carestation. Oxygen flow was kept at a rate of 10 L/min. The patient continued to take VCBs and EtO₂ recording was monitored. Number of breaths taken by patient was monitored simultaneously. When patient's EtO₂ reached, 90% patients were asked to take quite breath and the VCB count was noted. Monitoring of preoxygenation time and count of VCB was recorded by same anesthesiologist in every patient in TV and VC group, respectively. Another anesthesiologist conducted the preoxygenation in every patient of both groups.

Patients of TV and VC group were subdivided to different eight sub-groups as below (Figure 1).

1. TVB in T Male patients (T-M)
2. TVB in Non-T Male patients (NT-M)
3. TVB in T Female patients (T-F)
4. TVB in non-T Female patients (NT-F)
5. VCB in T Male patients (T-M)
6. VCB in NT Male patients (NT-M)
7. VCB in T Female patients (T-F)
8. VCB in NT Female patients (NT-F).

Data from these eight sub-groups were merged selectively to get data on total T and NT subgroups in both TV and VC groups.

In TV group, mean time to complete preoxygenation in T and NT, T-M and NT-M, T-F, and NT-F were compared by Mann–Whitney U-test. Percentage of patients completing preoxygenation in T and NT, T-M and NT-M, and T-F and NT-F in TV group was compared with Chi-square test.

In VC group, mean number of VC breaths to complete preoxygenation in T and NT, T-M and NT-M, and T-F and NT-F were compared by Mann–Whitney U-test. Percentage of patients completing preoxygenation in T and NT, T-M and NT-M, and T-F and NT-F was compared with Chi-square test.

RESULTS

In TV group, mean time to achieve 90% EtO₂ in T patients is 3.10±0.27 min (male 3.02±0.37 min, female 3.18±0.05 min) and in NT patients is 3.13±0.24 min (male 3.10±0.27 min, female 3.16±0.21 min). Range of time to complete preoxygenation was 3.00–3.35 min in T and 2.58–3.30 min in NT sub-group. Only two patients (2%) in T (22% male, 0% female) and two patients (4%) in NT (8% male and 0% female) achieved 90% EtO₂ in 3 min. Higher percentage of tribal male (22%) achieved complete preoxygenation than non-tribal male (8%) (P<0.01) (Table 1).

In VC group, mean number of VC breaths to achieve 90% EtO₂ in T patients is 8.32±0.60 (male 8.75±0.49, female 8.20±0.60) and in NT patients is 8.43±0.74 (male 8.23±0.70, female 8.60±0.72). Range of number of VC breath to complete preoxygenation was 7–9 in T and 7–10 in NT sub-group. Eight patients (53%) in T (20% male, 60% female) and 34 patients (62%) in NT (68% male and 57% female) achieved 90% EtO₂ in eight VC breaths. Higher percentage of non-tribal male (68%) achieved complete preoxygenation than tribal male (20%) (P<0.01) (Table 2).

DISCUSSION

Preoxygenation is a simple safety procedure during induction of anesthesia and intubation. Although some

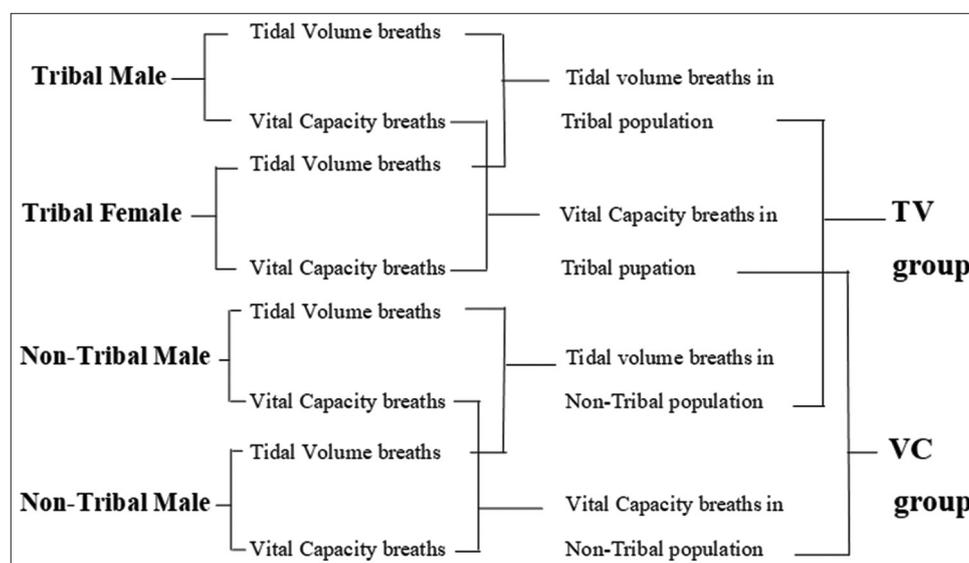


Figure 1: Groups and sub-groups

Table 1: Results of TV group

Tidal volume method						
Parameters		T		NT		P-value
No. of patients	17*	Male=9 (53%) [§] Female=8 (47%) [†]	53*	Male=24 (45%) [§] Female=29 (55%) [†]		–
Time to achieve EtO ₂ ≥90% (mean±SD) (minute)	3.10±0.27*	Male=3.02±0.37 [§] Female=3.18±0.05 [†]	3.13±0.24*	Male=3.10±0.27 [§] Female=3.16±0.21 [†]	0.80*	0.57 [§] 0.57 [†]
Range of time to achieve EtO ₂ ≥90% (minute)	3.00–3.35*	Male=2.58–3.16 [§] Female=3.02–3.30 [†]	2.58–3.30*	Male=3.00–3.33 [§] Female=3.00–3.35 [†]		–
Patients achieved EtO ₂ ≥90% at 3 min No. (%)	2 (22%)*	Male=2 (22%) [§] Female=0 (0%) [†]	2 (4%)*	Male=2 (8%) [§] Female=0 (0%) [†]	<0.01*	<0.01 [§]
Patients not achieved EtO ₂ ≥90% at 3 min No. (%)	15 (78%)*	Male=7 (78%) [§] Female=8 (100%) [†]	51 (96%)*	Male=22 (92%) [§] Female=29 (100%) [†]		–

*Represents T and NT, †represents Male subgroup of T and NT, ‡represents Female subgroup of T and NT, P-value of mean time of TV breaths to achieve EtO₂ ≥90% was calculated by Mann-Whitney U-test, P-value of no. (%) of patients achieved and not achieved EtO₂ ≥90% were calculated by Chi-Square test. It could not be calculated in female subgroup of TV group as the values were 0

Table 2: Results of VC group

Vital capacity method						
Parameters		T		NT		P-value
No. of patients	15*	Male=5 (33%) [§] Female=10 (67%) [†]	55*	Male=25 (45%) [§] Female=30 (55%) [†]		–
No. of VC breaths to achieve EtO ₂ ≥90% (mean±SD)	8.32±0.60*	Male=8.75±0.49 [§] Female=8.20±0.6 [†]	8.43±0.74*	Male=8.23±0.70 [§] Female=8.60±0.72 [†]	0.76*	0.42 [§] 0.16 [†]
Range of no. of VC breaths to achieve EtO ₂ ≥90%	7–9*	Male=8–9 [§] Female=7–9 [†]	7–10*	Male=7–10 [§] Female=8–10 [†]		–
Patients achieved EtO ₂ ≥90% in 8 VC breaths No. (%)	8 (53%)*	Male=1 (20%) [§] Female=6 (60%) [†]	34 (62%)*	Male=17 (68%) [§] Female=17 (57%) [†]	0.20*	<0.01 [§]
Patients not achieved EtO ₂ ≥90% in 8 VC breaths No. (%)	7 (47%)*	Male=4 (80%) [§] Female=4 (40%) [†]	21 (38%)*	Male=8 (32%) [§] Female=13 (43%) [†]		0.67*

*Represents T and NT, †represents Male subgroup of T and NT, ‡represents Female subgroup of T and NT, P-value of mean no. of VC breaths to achieve EtO₂ ≥90% was calculated by Mann-Whitney U-test, P-value of no. (%) of patients in subgroups and no. (%) of patients achieved and not achieved EtO₂ ≥90% were calculated by Chi-square test

patients may feel discomfort due to the airtight face mask, its benefit outweighs patients'. Heck Z et al.⁷ found that most patients tolerate preoxygenation well. Malik and Ali⁸ showed that preoxygenation during elective tracheal intubation is not a wastage of “anesthetic time.” A study by Mort TC showed that preoxygenation is worthy even before emergency tracheal intubation.⁶ There are two commonly practiced methods of preoxygenation: TVB method and VCB method. Both can be done by different circuits such as Magill circuit, Bain circuit, or circle absorption system. FGF with 100% O₂ to be kept at a rate of 8–10 L/min in both methods. Our aim was to validate the conventional two methods in different ethnic groups of eastern India.

In this study in TV group, the mean time to achieve EtO₂ more or equal to 90% in T sub-group was 3.00–3.35 min and in NT sub-group was 2.58–3.30 min. Only two patients (22%) in T group (2% in male and 0% in female), whereas two patients (4%) in NT group (8% in male and 0% in female) completed preoxygenation in 3 min.

Nimmagadda et al.,⁹ in 2001, found that in TVB, EtO₂ increased rapidly and plateaued by 2.5 min at 86%, 88%,

and 88% with 5, 7, and 10 L/min FGF, respectively. EtO₂ values of more or equal to 90% were attained between 3 and 4 min. They concluded that TV breath for 3–5 min was effective in achieving maximal preoxygenation. Finding of this study supports these study findings.

The AIDAA guideline recommended TVB for a minimum of 3 min with 100% O₂ at 10 L/min. If we practice national guideline, all of our patients will not complete preoxygenation. If we extend the process 0.35 min more, all patients will complete preoxygenation. This may not have importance in clinical practice. Those who did not complete preoxygenation were very close to completion. We observed that those who did not complete preoxygenation were close to completion of the preoxygenation process. We have not recorded the EtO₂ at the completion of 3 min as the study was not designed so from the beginning. Hence, no comment (or conclusive statement) can be done on this observation. Further, study with measurement of EtO₂ at the end of 3 min in all patients can throw light on it.

In a study by Kang et al.,¹⁰ in 2010, EtO₂ did not reach 90% in 180 s in the elderly group (more than 65 years)

during preoxygenation with the 3 min TVB technique. However, the young group (25–65 years) reached before 3 min. This study does not support our findings as majority of our participants (78% male and 100% female in T sub-group, 92% male and 100% female in NT sub-group) of 20–50 years age group did not complete preoxygenation within 3 min.

In this study, mean number of VCBs to achieve EtO₂ more than 90% in T group was 7–9 (8–9 in male and 7–9 in female) and in NT group was 7–10 (7–10 in male and 8–10 in female). Only eight patients (53%) in T sub-group (80% in male and 60% in female), whereas 34 patients (62%) in NT sub-group (68% in male and 57% in female) completed preoxygenation with 8 VCB.

Nimmagadda et al.,⁹ found that eight VCBs per min resulted in EtO₂ values of 82% and 87% at 7 and 10 L/min FGF, respectively. Extending deep breathing to 1.5 and 2 min with 10 L/min FGF increased EtO₂ by more or equal to 90%. Hence, findings of this study while using 10 L/min FGF are corroborative to this study.

Baraka et al.,¹¹ found that these TVB and maximal breathing (VCB) techniques are equivalent in terms of efficacy. Pandit et al.,¹² found that there were no significant differences in the mean±SD of maximum end-tidal fraction of oxygen between the 3-min and 8DB (Deep Breaths) methods. In the present study, more patients achieved preoxygenation in VC group (53% T patients and 62% NT patients) than TV group (22% T patients and 4% NT patients), though this was not analyzed statistically.

Kapart et al.,¹³ in 2019, performed a study on comparison of two techniques of preoxygenation, TV, and eight deep breath (DB) method. Their conclusion was that preoxygenation with 8 DBs in 1 min is a more effective method of preoxygenation, because there is a significant increase in the time taken for desaturation. This method will be more effective in patients with full stomach posted for emergency surgery. The conclusion from this study is similar, though it is not statistically proven.

According to AIDAA guidelines, eight VCB over 60 s is an alternative method of 3 min TVB. If we practice national guideline for VCB, all of our patients will not complete preoxygenation until we extend it two breaths more than the recommended breath count. Although patients did not complete preoxygenation, it was near complete stage. Hence, it may not be clinically significant.²

Limitations of the study

We did not record EtO₂ at the end of 3 min of TVB or at the end of 1 min in 8 VCB and oxygenation during apnea

following preoxygenation., Further study is required to know the oxygenation status during post-preoxygenation period in patients who reached and could not reach the end point of preoxygenation following conventional TV and VC methods.

CONCLUSION

Both of the conventional methods could not complete preoxygenation in all patients of eastern India. In TVB method, less than one-third of the study population completed the process of preoxygenation in a period of 3 min (22% tribal and 8% non-tribal male patients). None of the female patients in both sub-groups completed preoxygenation. In VCB technique, a higher proportion (20% male and 60% female from tribal sub-group, 68% male and 57% female from non-tribal sub-group) of patients achieved preoxygenation. Overall, a higher proportion of patients was found to complete the process of preoxygenation using the VCB.

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TRG- Concepts, design, manuscript writing, manuscript editing, review, data collection; **SS**- Manuscript writing, manuscript editing, review; **DG**- Manuscript writing, manuscript editing, review; **SM**- Manuscript writing, manuscript editing, literature search, data collection, statistical analysis; **DS**- Manuscript writing, manuscript editing, review.

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