DOI: 10.7860/JCDR/2025/82286.22153

Original Article

Anaesthesia Section

Comparison of Two-handed Mask Ventilation using C-E versus V-E Techniques for Induction of General Anaesthesia: A Randomised Clinical Trial

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ABSTRACT

Introduction: Mask ventilation is a fundamental skill in airway management, requiring optimal hand positioning for effective ventilation. Two-handed techniques are preferred for challenging mask ventilation scenarios.

Aim: To compare the effectiveness of the C-E versus the V-E techniques of two-handed mask ventilation during the induction of general anaesthesia.

Materials and Methods: This randomised clinical trial was conducted in the Department of Anaesthesiology at Dhiraj General Hospital, Vadodara, Gujarat, India from August 2024 to July 2025. Seventy adult patients (American Society of Anaesthesiologists (ASA) I-III, aged 18-60 years) undergoing elective surgery were randomly allocated into two groups: Group A (C-E technique, n=35) and Group B (V-E technique, n=35). The primary outcome measured was expired Tidal Volume (TVe). Secondary outcomes included peak airway pressure (Pmax), ease of ventilation score, haemodynamic parameters, and ventilation failure rates. Data were analysed using unpaired t-tests for continuous variables and the Chi-square test for categorical variables. A p-value of <0.05 was considered statistically significant.

Results: The groups were comparable in demographics (mean age: Group A-42.3±8.7 years vs. Group B-41.8±9.2 years, p-value=0.832; weight: 84.2±12.1 kg vs. 85.1±11.8 kg, p=0.751; BMI: 26.8±2.4 kg/m^2 vs. 27.2±2.6 kg/m^2, p-value=0.513). The mean TVe was significantly higher in the V-E group (677.9±76.8 mL) compared to the C-E group (450.7±71.2 mL; p-value<0.001). Peak airway pressures were similar between groups (C-E: 21.5±1.8 cmH_2O vs. V-E: 20.3±1.6 cmH_2O; p-value=0.074). The ease of ventilation score was significantly better with the V-E technique (4.2±0.6 vs. 2.7±0.8; p-value<0.001). Ventilation failure occurred in five patients (14.3%) with the C-E technique and none with the V-E technique.

Conclusion: The V-E technique provides superior ventilation with higher tidal volumes, better ease of ventilation, and lower failure rates compared to the C-E technique during mask ventilation. The V-E technique achieved 50% higher tidal volumes without requiring increased airway pressures, demonstrating superior ventilation efficiency. This technique should be preferentially used for two-handed mask ventilation in clinical practice.

Keywords: Airway management, Thenar eminence, Two-handed technique

INTRODUCTION

Mask ventilation is a necessary skill required for successful airway management [1]. Effective mask ventilation necessitates a patent airway, proper positioning, and a sufficient mask seal. It can be performed in apneic patients undergoing general anaesthesia. Following the induction of general anaesthesia, airway obstruction may occur due to the falling of the tongue and soft palate. This obstruction can be overcome by maneuvering the mandible and inserting airway devices [2]. Thus, maintaining a good face mask seal is fundamental for adequate ventilation.

There are multiple approaches to hand positioning during mask ventilation: the one-handed technique and the two-handed technique. Two-handed techniques are often employed in cases of difficult mask ventilation scenarios [3]. The C-E and V-E techniques are two common methods of two-handed mask ventilation. In the C-E technique, the mask is applied by forming a “C” shape with the thumb and index finger over each side of the mask, while the third, fourth, and fifth fingers of both hands lift the mandible, creating an “E” shape. In the V-E technique, the thumb and thenar eminence of each hand are placed over each side of the mask, while the second to fifth fingers collectively pull the jaw upward, also forming an “E” shape [4].

Mask ventilation plays a crucial role in saving patients’ lives. The importance of optimising the skill of mask ventilation should be emphasised, as effective mask ventilation can minimise or reverse hypoxia, particularly when successful intubation is impossible [5]. The recent 2022 ASA guidelines stress the significance of optimised face mask ventilation, including two-handed mask grip techniques [6].

Recent studies have shown conflicting results regarding the superiority of different mask ventilation techniques. A 2023 study by Balafar M et al., compared the E/C, T/E, and a novel hook technique in 492 emergency department patients, finding that the hook technique provided superior ventilation volumes [7]. Meanwhile, Saroye N et al., evaluated the efficacy of two bag-mask ventilation techniques by novice airway providers, demonstrating better performance with thenar eminence techniques [8]. Despite these findings, direct comparisons of the C-E and V-E techniques in an operating room setting remain limited, particularly in the Indian population, where anatomical variations may influence technique effectiveness [4,5,9,10].

This randomised clinical trial was designed to directly compare these techniques, thereby providing clearer insights to guide clinical practice and training. The present study aimed to determine and compare the effectiveness of the C-E and V-E techniques of mask ventilation during the induction of general anaesthesia. The primary outcome measured was the expired Tidal Volume (TVe). Secondary outcomes included Peak airway pressure (Pmax), ease of ventilation

score, chest expansion score, haemodynamic parameters, and ventilation failure rates.

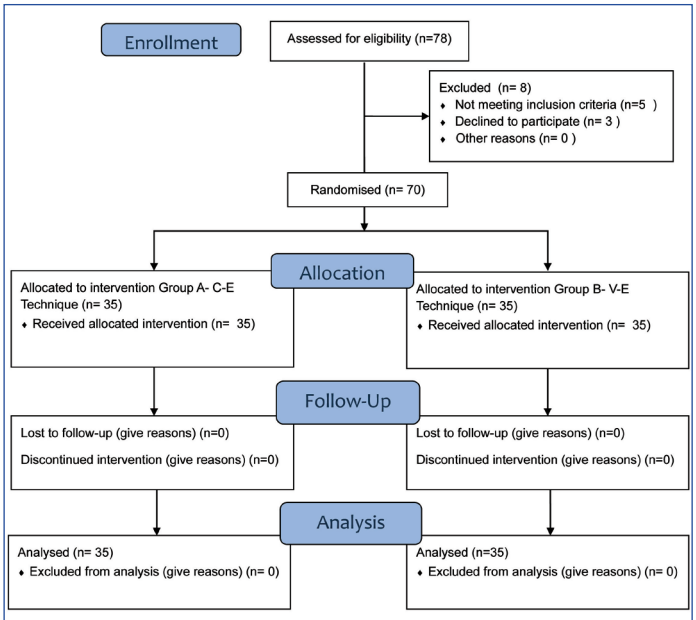
MATERIALS AND METHODS

This randomised, single-blinded clinical trial was conducted in the Department of Anaesthesiology at Dhiraj General Hospital, SBKS Medical Institute and Research Centre, Pipariya, Vadodara, Gujarat, India from August 2024 to July 2025, after receiving approval from the Institutional Ethics Committee (Ethics approval number: SBKS/ON/MEDI/RP/July/24/69). Written informed consent was obtained from all patients.

Inclusion criteria: Patients with ASA physical status I, II, or III, aged between 18-60 years of either gender, who were scheduled for elective surgery under general anaesthesia were included in the study.

Exclusion criteria: Patients with acute or chronic respiratory disorders, a beard, temporomandibular jaw abnormalities, were edentulous, had limited mandibular protrusion, had an airway mass or tumour, or were pregnant were excluded from the study. These exclusion criteria were applied to ensure patient safety and to minimise confounding variables that could affect the quality of mask ventilation.

The flowchart of this study is depicted in the CONSORT diagram [Table/Fig-1].



[Table/Fig-1]: CONSORT flow diagram.

Sample size calculation: Based on an expected mean difference of 150 mL in expired tidal volume between groups, with a standard deviation of 75 mL, α=0.05, and power=80%, the calculated sample size was 32 patients per group. To account for potential dropouts, 35 patients were enrolled in each group.

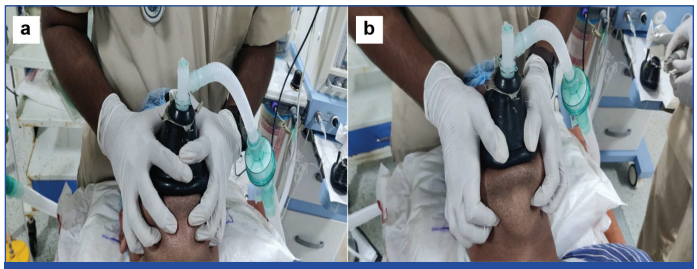
$n=2\times(Z\alpha/2+Z\beta)^2\times\sigma^2/(\mu_1-\mu_2)^2$

Where:

- n = sample size per group
- $Z\alpha/2$ = critical value for type I error (1.96 for α = 0.05)
- $Z\beta$= critical value for type II error (0.84 for β=0.20, power=80%)
- σ = pooled standard deviation (75 mL)
- $\mu_1-\mu_2$=expected difference in means between groups (150 mL) Calculation: $n=2\times(1.96+0.84)^2\times(75)^2/(150)^2$ $n=2\times(2.8)^2\times5625/22500$ $n=2\times7.84\times5625/22500$ $n=88,200/22500$ $n=3.92 \approx 32$ patients per group

Randomisation: Patients were randomly allocated using computer-generated random numbers into two groups:

- Group A: C-E technique (n=35) [Table/Fig-2a]
- Group B: V-E technique (n=35) [Table/Fig-2b]



[Table/Fig-2]: (a) C-E technique; (b) V-E technique.

Randomisation was performed by a research coordinator not involved in patient care. Allocation concealment was maintained using sealed opaque envelopes. Due to the nature of the intervention, blinding of the operator was not possible. However, outcome assessors were blinded to group allocation.

Anaesthetic technique: A preanaesthetic evaluation was performed by obtaining the patient's history and conducting a complete physical examination, followed by blood investigations, a chest X-ray, and an Electrocardiogram (ECG). After obtaining informed written consent, the patient was kept NBM (nil by mouth) for eight hours. On the day of surgery, intravenous access was obtained using an 18-gauge IV cannula, and a Ringer's lactate infusion was started in the recovery room. In the operating theatre, the patient was placed in a supine position with their head in a neutral position on a pillow of 10 cm height. Preoperative haemodynamic vitals such as pulse, non invasive blood pressure, Oxygen Saturation (SpO_2), and End-Tidal Carbon Dioxide ($ETCO_2$) were observed. Preoxygenation was performed using 100% O_2 at 6 L/min for three minutes. Premedication included glycopyrrolate 0.2 mg IV, ondansetron 4 mg IV, midazolam 1 mg IV, and fentanyl 1-2 µg/kg IV. Anaesthesia was induced with propofol 2-2.5 mg/kg IV, followed by atracurium 0.5 mg/kg IV. Patients were ventilated using volume control mode with a tidal volume of 8 mL/kg, a respiratory rate of 12 breaths/minute, and PEEP of 0 mmHg.

Intervention: Mask ventilation was performed by an experienced anaesthesiologist (more than 5 years of experience) for three minutes using the allocated technique. If ventilation failed, a nasopharyngeal or oropharyngeal airway was inserted, and the subject was excluded from the study. No patients from Group A required airway insertion due to ventilation failure and were excluded from the final analysis. Parameters were recorded at 30 seconds, one minute, 1.5 minutes, two minutes, 2.5 minutes, and three minutes.

Outcome measures:

- Primary : Expired tidal volume (TVe)
- Secondary: Peak airway pressure (Pmax), ease of ventilation score (1-5 Likert scale), chest expansion score (1-4 scale: 1=minimal expansion (0-25%); 2=moderate expansion (25-50%); 3=good expansion (50-75%); 4=excellent expansion (75-100%), as described by Balafar M et al., haemodynamic parameters, $ETCO_2$, SpO_2, ventilation failure rates [7].

After mask ventilation, the patient was intubated with an endotracheal tube, and bilateral air entry was confirmed. The patient was then placed on a ventilator, and anaesthesia was maintained with isoflurane and intermittent atracurium doses. Upon completion of the surgery, neuromuscular blockade was reversed using neostigmine 0.05 mg/kg with glycopyrrolate 0.01 mg/kg after the return of the train-of-four response. Extubation was performed after meeting standard criteria, including a sustained head lift of more than 5 seconds and tidal volume greater than 5 mL/kg.

STATISTICAL ANALYSIS

Data were analysed using Statistical Package for the Social Sciences (SPSS) version 23.0. Continuous variables were expressed as mean±standard deviation and compared using an

unpaired student's t-test. Categorical variables were expressed as frequencies and percentages and compared using the Chi-square test or Fisher's exact test as appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 78 patients were assessed for eligibility, of which eight were excluded (5 did not meet the inclusion criteria, and 3 declined to participate). All 70 randomised patients completed the study with no dropouts or protocol violations.

Both groups were comparable regarding demographic characteristics, with no significant differences in age, weight, gender distribution, BMI, ASA grading, or Mallampati classification (p-value >0.05) [Table/Fig-3].

Parameters	Group A (C-E) n=35	Group B (V-E) n=35	p-value
Age (years)	42.3±8.7	41.8±9.2	0.832
Weight (kg)	84.2±12.1	85.1±11.8	0.751
Height (cm)	168.4±7.2	169.1±6.8	0.694
BMI (kg/m²)	26.8±2.4	27.2±2.6	0.513
Gender M/F	18/17	16/19	0.625
ASA I/II/III	22/11/2	20/13/2	0.784
Mallampati I/II/III	24/9/2	26/7/2	0.712

[Table/Fig-3]: Demographic and baseline characteristics.
Values are presented as mean±SD or numbers. Unpaired Student's t-test was used for statistical and Chi-square test for categorical variables p-value: p<0.05* statistically significant

The V-E technique demonstrated consistently and significantly higher expired tidal volumes compared to the C-E technique across all time points. The mean difference of 227.2 mL represents a 50.4% improvement in ventilation efficiency with the V-E technique [Table/Fig-4]. Secondary outcomes are presented in [Table/Fig-5]. Peak airway pressures were similar between groups, indicating that the improved tidal volumes with the V-E technique were achieved without requiring higher pressures. $ETCO_2$ levels were significantly higher with the V-E technique, indicating better alveolar ventilation. Operator-rated ease of ventilation was significantly better with the V-E technique.

Time point	Group A (C-E) mL	Group B (V-E) mL	Mean difference	p-value
30 seconds	445.2±69.8	672.4±74.2	227.2	<0.001
1 minute	448.6±70.4	675.8±76.1	227.2	<0.001
1.5 minutes	447.1±71.8	674.3±77.4	227.2	<0.001
2 minutes	451.3±72.1	678.9±78.2	227.6	<0.001
2.5 minutes	454.2±73.6	681.1±79.1	226.9	<0.001
3 minutes	457.8±74.2	684.7±80.3	226.9	<0.001
Overall mean	450.7±71.2	677.9±76.8	227.2	<0.001

[Table/Fig-4]: Primary outcome - expired tidal volume at different time points.
Values are presented as mean ± SD or numbers. Unpaired Student's t-test was used for statistical analysis p-value: p<0.001** statistically highly significant

Parameter	Group A (C-E)	Group B (V-E)	p-value
Peak Airway Pressure (cmH_2O)	21.5±1.8	20.3±1.6	0.074
$ETCO_2$ (mmHg)	30.4±2.1	32.8±2.3	<0.001
SpO_2 (%)	97.2±1.1	98.8±0.9	<0.001
Ease of ventilation score	2.7±0.8	4.2±0.6	<0.001
Chest expansion score	2.8±0.7	4.3±0.5	<0.001
Ventilation Failure n (%)	5 (14.3%)	0	0.026

[Table/Fig-5]: Secondary outcomes - Ventilatory parameters.
Values are presented as mean±SD or numbers. Unpaired Student's t-test was used for statistical and Chi-square test for categorical variables p-value: p<0.05* statistically significant

Haemodynamic parameters: [Table/Fig-6] remained stable and comparable between both groups throughout the study period, indicating that neither technique caused significant cardiovascular stress.

Parameter	Group A (C-E)	Group B (V-E)	p-value
Heart rate (bpm)	89.4±12.2	87.1±11.8	0.423
Systolic BP (mmHg)	132.6±18.4	128.9±17.2	0.385
Diastolic BP (mmHg)	84.2±10.1	82.7±9.8	0.526
Mean BP (mmHg)	100.3±12.7	98.1±11.9	0.458

[Table/Fig-6]: Haemodynamic parameters.
Values are presented as mean ± SD or numbers. Unpaired Student's t-test was used for statistical analysis p-value: p<0.001** statistically highly significant.

DISCUSSION

The present study demonstrated the clear superiority of the V-E technique over the C-E technique for two-handed mask ventilation. The V-E technique achieved 50% higher tidal volumes (677.9±76.8 mL vs. 450.7±71.2 mL, p-value <0.001) without requiring increased airway pressures. This finding has important clinical implications for both routine practice and emergency airway management.

The superior ventilation efficiency observed with the V-E technique can be attributed to several anatomical and mechanical factors. The placement of the thenar eminence on the mask creates a broader contact area, improving seal quality. Additionally, positioning the fingers away from the submandibular soft tissues prevents compression of the upper airway structures. The V-E grip also facilitates a better jaw thrust maneuver, which is crucial for maintaining airway patency [4,11].

Comparison with recent literature reveals consistent findings supporting thenar eminence-based techniques. Bharadwaj MS et al., reported similar results in obese patients, with the V-E technique generating tidal volumes of 702±77 mL compared to 492±72 mL with the C-E technique [5]. Appukuttan V et al., found the modified thenar eminence technique to be superior to conventional methods (370±55 mL vs. 313±50 mL) [12]. Ramakkannu K et al., demonstrated improved efficacy of the two-handed jaw thrust technique over the one-handed C-E technique [13]. These studies collectively support the anatomical advantages of thenar eminence positioning.

An important finding was that improved ventilation with the V-E technique occurred without increased peak airway pressures (20.3±1.6 vs. 21.5±1.8 cm H_2O, p-value =0.074). This indicates enhanced ventilation mechanics through better airway patency rather than forceful ventilation. The significantly higher $ETCO_2$ levels with the V-E technique (32.8±2.3 vs. 30.4±2.1 mmHg, p-value <0.001) further confirm superior alveolar ventilation. The ease of ventilation scores (4.2±0.6 vs. 2.7±0.8, p-value <0.001) suggest that operators find the V-E technique more ergonomic and sustainable, which is crucial during prolonged ventilation scenarios [14,15].

Appukuttan V et al., found that the VTE correlated with $ETCO_2$, which was measured at 33±3 mmHg in the modified thenar eminence technique and 31±3 mmHg in the conventional thenar eminence technique (p-value=0.01) [12]. The PMAX was 15.2±2.2 cm H2O with the modified technique and 15.1±2.1 cm H_2O with the conventional technique, showing no significant difference. Similarly, Gerstein NS et al., in their evaluation of various mask ventilation techniques among healthcare professionals, reported no significant difference in PMAX between the C-E grip (where the middle, ring, and little fingers form an "E" under the mandible to lift it upward, while the thumb and index finger form a "C" to secure the mask) and the thenar eminence (V-E) technique [14]. There is no clear explanation for the comparable PMAX and $ETCO_2$ observed in the present study.

The complete absence of ventilation failures with the V-E technique, compared to a 14.3% failure rate with the C-E technique, has significant safety implications. This aligns with the 2022 ASA difficult airway guidelines [6], which emphasise the optimisation of mask

ventilation techniques. Various techniques have been evaluated to improve mask ventilation success [16-18]. The incidence of difficult mask ventilation in general surgical populations ranges from 1.4% to 5% [19], making the zero-failure rate with the V-E technique particularly noteworthy. Modifications to one-handed techniques have also shown that thenar eminence positioning improves effectiveness [20]. Similar ventilation advantages have been demonstrated in paediatric populations with two-person techniques [21] and in simulation studies comparing hand-sealing methods [22].

The haemodynamic stability observed with both techniques confirms their safety profile, though the V-E technique offers superior ventilation efficacy. In this study, haemodynamic parameters (heart rate and blood pressure) remained stable and comparable between the C-E and V-E techniques, indicating that neither technique imposed additional cardiovascular stress. This stability likely reflects effective ventilation without excessive airway pressure or sympathetic stimulation. Present study findings are consistent with Bharadwaj MS et al., who also reported no significant haemodynamic differences between the two techniques [5].

Limitation(s)

The present study was conducted in patients with normal airways and may not be generalisable to patients with predicted difficult airways. The study was not blinded to the operator, which could introduce bias. The sample size was calculated for the primary endpoint only, and the study may be underpowered for some secondary endpoints. Based on the findings of this study, the V-E technique should be considered the preferred method for two-handed mask ventilation during routine anaesthesia induction and as a rescue technique in difficult ventilation scenarios. Training programs should emphasise V-E technique proficiency among anaesthesia providers.

CONCLUSION(S)

The V-E technique of two-handed mask ventilation is superior to the C-E technique in terms of expired tidal volume, ease of ventilation, and failure rates during induction of general anaesthesia. The technique provides more efficient ventilation without requiring higher airway pressures, making the V-E technique a safer and more reliable option for both routine anaesthesia practice and emergency airway management. Adoption of this technique may enhance patient safety, particularly in situations where effective ventilation is critical.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Jul 30, 2025
- Manual Googling: Oct 06, 2025
- iThenticate Software: Oct 08, 2025 (13%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Jul 24, 2025**
Date of Peer Review: **Aug 24, 2025**
Date of Acceptance: **Oct 10, 2025**
Date of Publishing: **Dec 01, 2025**