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Original Research Article

Comparison of Two Techniques of Mask Holding: EO and EC Clamp Technique During Face Mask Ventilation in Anaesthetised and Paralysed Patients

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Abstract:

Background: Effective face mask ventilation is essential for maintaining oxygenation during general anaesthesia. Achieving an adequate mask seal can be challenging, particularly for inexperienced personnel. The EO technique has been proposed as an alternative to the conventional EC clamp technique to improve ventilation efficacy.

Methods: This comparative study included 42 patients aged 18–65 years with American Society of Anesthesiologists (ASA) physical status I–II, scheduled for elective surgeries under general anaesthesia. Preoperative airway assessment included Mallampati classification, thyromental distance, and temporomandibular joint evaluation. A volunteer with limited experience in bag-mask ventilation (fewer than five previous attempts) performed ventilation using both EO and EC clamp techniques. Five breaths were delivered with each technique at an oxygen fresh gas flow of 6 L/min. Tidal volume, minute ventilation, audible epigastric leak, and audible mask leak were assessed.

Results: The EO technique demonstrated significantly higher tidal volume than the EC clamp technique (520.62 vs. 498.29 mL; $p < 0.001$). Similarly, minute ventilation was significantly greater with the EO technique than with the EC technique (7.81 vs. 7.47 L/min; $p < 0.001$). Audible epigastric leaks were observed in three patients with each technique. Audible mask leaks occurred in seven patients with the EO technique and 19 patients with the EC clamp technique. Among patients experiencing audible mask leaks with the EC technique, the EO technique achieved an improved mask seal in 12 patients.

Conclusion: The EO technique provided significantly higher tidal volumes and minute ventilation, with fewer audible mask leaks, compared with the conventional EC clamp technique. Therefore, the EO technique may be a more effective approach for single-handed face mask ventilation by inexperienced personnel in anaesthetised and paralysed patients.

Keywords: Face Mask Ventilation, EO Technique, EC Clamp Technique, Tidal Volume, Minute Ventilation, Mask Seal, General Anaesthesia.

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Introduction

The most fundamental of airway management skills is providing artificial ventilation to an unconscious and apnoeic patient via a mask placed on the patient's face. After achieving purposeful apnoea, nearly all general anaesthetic patients require mask ventilation for a period of time.[1] Unintentional apnoea, which typically occurs as a result of cardiac arrest or trauma, necessitates mask ventilation and can occur outside of the operating room, in the emergency room, or during prehospital field resuscitation.[2]

For BMV (Bag and Mask Ventilation), one hand is used to hold the mask over the victim's face in such a way that the little finger provides jaw thrust while the ring and middle fingers rest softly on the rim of the mandible forming an E shape while the thumb and index finger form a C shape, attempting to secure the mask tightly around the victim's mouth and nose.[3] This approach is known as the EC clamp technique, in which one hand holds the mask while the other squeezes the bag (a self-inflating bag or a reservoir bag).

Due to air leaks around the mask and during the ventilation process with bag and mask by unskilled personnel, the EC technique is not always reliable. A suitable mask does not conceal the patient's eyes and does not extend down past the chin. In addition, the patient's appropriate position is critical for proper bag and mask ventilation. When unconscious patients need to be ventilated with a bag and mask, the tongue is an obstructive component.[4]

It is critical to discover a suitable BMV strategy to solve this challenge. As previously stated, EC has been regarded as a conventional BMV approach. Other techniques, such as thenar eminence and EO, have recently been introduced. Furthermore, because some medical personnel are unfamiliar with the ventilation process, finding a simple and accessible method appears to be a difficult task. The purpose of this study is to compare two mask ventilation procedures, the EO and EC clamp techniques, among untrained medical staff.

Aims and Objectives: The aim of the study was to compare the efficacy of the E-O (Eye-Opening) and E-C (E-C Clamp) techniques of face mask holding during mask ventilation by novices in anaesthetized and paralyzed patients. The primary objective is to evaluate and compare the effectiveness of the mask seal using the average tidal volume and minute ventilation achieved with each technique. The secondary objective is to assess the occurrence of air leaks by identifying audible mask leaks, audible epigastric leaks, and inadequate mask ventilation associated with each technique.

Materials and Methods

Study Design: This observational study was conducted in the Department of Anaesthesiology, Sree Gokulam Medical College and Research Foundation. The study population included patients aged 18–65 years, of either sex, belonging to American Society of Anesthesiologists (ASA) physical status I or II, who were scheduled to undergo various elective surgical procedures under general anaesthesia (GA).

Inclusion and Exclusion Criteria: The study included male and female patients aged 18–65 years with American Society of Anesthesiologists (ASA) physical status I or II who were scheduled to undergo elective surgery under general anaesthesia at Sree Gokulam Medical College and Research Foundation. Patients with an anticipated difficult airway, increased risk of aspiration, body mass index (BMI) greater than 35 kg/m², or pregnancy were excluded from the study. Patients who refused to participate were also excluded.

Sample Size Calculation: A sample size of 42 members fulfilling the inclusion criteria, was included in this study.

Sample size was calculated from the below equation,

From Umesh et al. (2018) [1] average tidal volume according to EC technique is $\mu1=239.56$ with standard deviation ($\sigma1$) = 103.95

Average tidal volume according to EO technique $\mu2=286.12$ with standard deviation ($\sigma2$)=107.41

$$n=\frac{(z_{1-\alpha/2}+z_{1-\beta})^2}{\Delta^2}+\frac{z^2_{1-\alpha/2}}{2}$$

$$\Delta=\frac{(\mu2-\mu1)}{\sigma}$$

$$\sigma=\frac{\sigma1+\sigma2}{2}$$

$\alpha=5\%$

$\beta=20\%$

$z1-\alpha/2 = 1.96$

$z1-\beta=0.842$

So, n=42

Data Collection Procedure: After obtaining ethical committee approval and informed written consent, 50 patients aged 18–65 years with ASA physical status I or II, scheduled for elective surgery under general anaesthesia, were enrolled in the study. Patients were assessed preoperatively for airway characteristics, including Mallampati classification, thyromental distance, temporomandibular joint mobility, mouth opening, neck movements, beard, edentulous status, obstructive sleep apnoea, and neck circumference. Following standard premedication, induction of anaesthesia, and administration of neuromuscular blockade, an experienced anaesthesiologist confirmed effective single-handed bag-mask ventilation using an appropriately sized oropharyngeal airway. Medical interns and anaesthesia technician students with limited prior experience in bag-mask ventilation performed ventilation using both the EC clamp and EO techniques. Five breaths were delivered with each technique using standardized ventilator settings and an oxygen flow of 6 L/min. During ventilation, tidal volume, minute ventilation, audible mask leaks, epigastric sounds, and adequacy of ventilation were assessed, while the participants maintained their hand positions and adjusted head tilt or chin lift as required. After data collection, the trachea was intubated by an experienced anaesthesiologist, and any difficulties encountered during laryngoscopy or intubation were documented.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using SPSS software. Qualitative variables were expressed as frequencies and percentages, while quantitative variables were presented as mean and standard

deviation (SD). Qualitative variables were compared using McNemar's test, and quantitative variables were compared using the paired t-test.

Results

A comparative study of techniques involving 42 patients was undertaken to investigate the efficacy and efficiency of EO and EC clamp techniques during face-mask ventilation.

Table 1: Demographic Characteristics of the Patients

Characteristic	Category	Frequency (n)	Percentage (%)
Overall	All patients	42	100
Age	35 and below	14	33.3
Age	36–45	7	16.7
Age	46–55	11	26.2
Age	55 and above	10	23.8
Gender	Male	18	42.9
Gender	Female	24	57.1
ASA physical status	I	23	54.8
ASA physical status	II	19	45.2

Table 1 illustrates the demographic profile of the 42 study participants. The largest age group was 35 years and below (14; 33.3%), followed by those aged 46–55 years (11; 26.2%). There were 24 females (57.1%) and 18 males (42.9%). Most patients were classified as ASA physical status I (23; 54.8%), while 19 (45.2%) were ASA II.

Table 2: Descriptive statistics for age and BMI

Variable	N	Minimum	Maximum	Mean	SD
Age	42	18.00	69.00	42.9524	14.02776
BMI	42	1.00	4.00	2.4048	1.19060

Table 2 presents the descriptive statistics for age and BMI. The mean age of the participants was 42.9524 years (SD 14.02776), with values ranging from 18.00 to 69.00 years. The BMI values are reproduced exactly as reported in the source file.

Table 3: Airway Assessment Parameters

Parameter	Category/finding	Frequency (n)	Percentage (%)
Modified Mallampati classification (MPC)	Class 1	12	28.6
Modified Mallampati classification (MPC)	Class 2	30	71.4
Thyromental distance (TMD)	3 fingers	42	100.0
Mouth opening (MO)	3 fingers	42	100.0
Temporomandibular joint mobility (TMJ)	1 finger	42	100.0
Neck movements (Neck_Rom)	Full	42	100.0
Dentition	Normal	42	100.0
Beard	Present	4	9.5
Beard	Absent	38	90.5

Table 3 observes the preoperative airway assessment findings. Modified Mallampati class 2 was recorded in 30 patients (71.4%), while class 1 was recorded in 12 (28.6%). All 42 patients (100%) had a thyromental distance and mouth opening of three fingers, temporomandibular joint mobility of one finger, full neck movements, and normal dentition. A beard was present in 4 patients (9.5%) and absent in 38 (90.5%).

Table 4: Comparison of Individual Tidal Volumes between EO and EC Techniques

Breath Pair	Technique	N	Mean	SD	p-value
Pair 1	EO	42	520.62	69.63632	<0.001
Pair 1	EC	42	498.29	56.09977	<0.001
Pair 2	EO	42	513.98	61.53543	<0.001
Pair 2	EC	42	497.50	54.87425	<0.001
Pair 3	EO	42	519.24	60.69669	<0.001
Pair 3	EC	42	493.79	60.09405	<0.001
Pair 4	EO	42	517.86	62.2887	<0.001
Pair 4	EC	42	494.12	55.0442	<0.001
Pair 5	EO	42	518.71	62.92515	<0.001
Pair 5	EC	42	495.02	55.42804	<0.001

Table 4 compares tidal volumes for the five consecutive breath pairs using the EO and EC techniques. The mean tidal volume was higher with EO than with EC in every pair. The reported p-value was <0.001 for each comparison, indicating statistically significant differences between the techniques.

Table 5: Comparison of Individual Minute Ventilation between EO and EC Techniques

Breath Pair	Technique	N	Mean	SD	p-value
Pair 1	EO	42	7.8074	1.04414	<0.001
Pair 1	EC	42	7.4714	0.83948	<0.001
Pair 2	EO	42	7.7057	0.91552	<0.001
Pair 2	EC	42	7.4594	0.81966	<0.001
Pair 3	EO	42	7.7875	0.91113	<0.001
Pair 3	EC	42	7.4046	0.90183	<0.001
Pair 4	EO	42	7.7668	0.93441	<0.001
Pair 4	EC	42	7.4087	0.82287	<0.001
Pair 5	EO	42	7.7781	0.93852	<0.001
Pair 5	EC	42	7.4233	0.83006	<0.001

Table 5 presents the minute ventilation values for the five breath pairs. Mean minute ventilation was higher with the EO technique than with the EC technique in all five pairs. Each comparison had a reported p-value of <0.001, demonstrating statistically significant differences in favour of EO.

Table 6: Comparison of Audible Epigastric Leak (AEL) between EO and EC Techniques

EO AEL Status	EC AEL Present	EC AEL Absent	Total
Present	3	0	3
Absent	0	39	39
Total	3	39	42

Table 6 illustrates the comparison of audible epigastric leak between the two techniques. AEL was present in 3 patients with both EO and EC, and absent with both techniques in 39 patients. No discordant cases were recorded in the cross-tabulation. The table reports a chi-square value of 42.000, 1 degree of freedom, and p <0.001.

Table 7: Comparison of Audible Mask Leak (AML) between EO and EC Techniques

EO AML Status	EC AML Present	EC AML Absent	Total
Present	7	0	7
Absent	12	23	35
Total	19	23	42

Table 7 compares audible mask leak between EO and EC techniques. AML was present with both techniques in 7 patients and was absent with both techniques in 23 patients. Among the 19 patients with AML during EC, 12 had no AML with EO; no patients with AML during EO had no AML with EC. The study reports a chi-square value of 10.168, 1 degree of freedom, and p = 0.001.

Discussion

Establishing a secure airway has long been a priority in patient care. BMV is an essential part of airway management, both in patients under general anaesthesia and in those needing emergency airway support. It provides oxygenation and ventilation until a definitive airway is secured, and it is valued by rescuers for its life-saving potential. Endotracheal intubation has not been shown to improve survival in traumatised patients (Weiss and Lutes).[3] Effective BMV depends on holding the mask securely over the mouth and nose and delivering positive-pressure breaths, and it is usually combined with oral or nasal airways.[5] Three problems limit adequate BMV: inadequate volume of air delivered, poor oxygenation, and gastric distension. A complete mask seal over the mouth and nose addresses the first two.[5] Under general anaesthesia, oropharyngeal muscle tone falls and the tongue, soft palate and epiglottis collapse, causing airway obstruction. Edentulous patients are at higher risk of obstruction and difficult BMV than dentate patients. [5,6-8] Three techniques are in practice: the thenar eminence, EC and EO techniques.[3]

In this study of 42 patients, we compared the EO and EC clamp techniques of mask holding performed by inexperienced personnel. The volunteers had seen BMV performed but had done it fewer than five times. Five breaths were delivered with each technique at a fresh gas flow of 6 L/min oxygen. The EO technique gave significantly higher tidal volumes than the EC technique for all five breaths (Pair 1: 520.62 vs. 498.29 mL; Pair 2: 513.98 vs. 497.50 mL; Pair 3: 519.24 vs. 493.79 mL; Pair 4: 517.86 vs. 494.12 mL; Pair 5: 518.71 vs. 495.02 mL;

P < 0.001 for all). Minute ventilation was also higher with EO (Pair 1: 7.81 vs. 7.47 L/min; Pair 2: 7.71 vs. 7.46; Pair 3: 7.78 vs. 7.40; Pair 4: 7.76 vs. 7.41; Pair 5: 7.78 vs. 7.42; P < 0.001 for all). These findings indicate a better mask seal with EO in novice hands.

AEL (Audible Epigastric Leak) occurred in three patients with the EC grip and three with the EO grip. Neither grip resolved the leak in the patients who had AEL with the other, so the two techniques did not differ for gastric insufflation. AML was more frequent with EC: 19 patients had AML with EC grip against 7 with EO grip (P = 0.001, McNemar test). Of the 19 patients with AML on EC, the EO grip gave a better seal (no AML) in 12. Of the 7 with AML on EO, the EC grip gave a better seal in none. The EO technique therefore achieved a better mask seal.

Our results agree with those of Umesh et al.,[9] who conducted a double-blind, randomised, prospective crossover trial in 60 patients, comparing the EO and EC techniques in anaesthetised and paralysed patients. A novice with fewer than five attempts at BMV held the mask with each technique, and the ventilator delivered five breaths at a set pressure control of 15 cm H2O, with one second each for inspiration and expiration. They reported significantly better tidal volume and minute ventilation with EO (P = 0.001; tidal volume difference 46 mL; minute volume difference 0.51 L). They concluded that, in the absence of other factors causing difficult mask ventilation, EO gives a better seal than EC during single-handed mask holding by beginners. Our mean tidal volume advantage (about 16–26 mL across the five breaths) and minute ventilation advantage (about 0.25–0.38 L/min) were smaller than theirs, but the direction and significance of the effect were the same. The same group had earlier shown that the EO technique was superior to EC in manikins during single-person BMV by novices.[1] Gerstein et al. also studied facemask ventilation techniques in novice providers.[2]

Soleimanpour et al. [3] compared the E-C, E-O and thenar eminence techniques in a manikin study of 100 participants, divided into novices and seniors. Ventilation quality was assessed by chest rise and by scores from two reviewers, on a scale of 1 to 4. Male participants made up 27% of the undergraduate group and 59% of the senior group, and the mean ages were 24 and 33.5 years respectively (P > 0.05). The novice group performed best with the E-O technique, and the authors suggested that training in this technique could be included in undergraduate curricula. This is consistent with our finding that novices achieve a better seal with EO.

Studies of two-handed techniques also support the importance of a good mask seal. Joffe et al. [10] compared a one-handed EC-clamp technique with a two-handed jaw-thrust technique in 42 elective surgical patients during pressure-controlled ventilation. Minute ventilation was 6.32 ± 3.24 L/min with one hand and 7.95 ± 2.70 L/min with two hands. Tidal volume was 6.80 ± 3.10 mL/kg with one hand and 8.60 ± 2.31 mL/kg with two hands. Inadequate or dead-space ventilation was more frequent with the one-handed technique (14% vs. 5%; P = 0.013). Jain et al. [11] studied children under two years and found expired tidal volumes of 6.8 (2.5), 7.9 (2.4) and 8.9 (1.8) mL/kg with single-hand C-E, two-hand C-E and V-E respectively (P < 0.001). Failure to ventilate occurred in 5/30 (16.6%), 2/30 (6.6%) and 0/30 respectively (P < 0.001). In obese adults (mean BMI 37 kg/m²), Fei et al. [12] reported a 44% failure rate with the C-E technique and 0% with the modified V-E technique (P < 0.001). Tidal volume was 371 mL with C-E and 720 mL with V-E (P < 0.001), at similar peak airway pressures of 21 cm H2O. Davidovic et al. [13] found that 2-person bag-valve-mask ventilation produced greater mean tidal volumes per weight than the 1-person technique on infant and child manikins (7.2 vs. 5.9 mL/kg in infants; 8.8 vs. 6.1 mL/kg in children). Mean peak pressures were also higher (27.4 vs. 22.0 cm H2O in infants; 27.2 vs 21.8 cm H2O in children). Hart et al. [4] enrolled 70 participants and reported median volumes of 428.4 mL for the one-handed C-E technique, 550.8 mL for two-handed C-E and 538 mL for two-handed V-E (P < 0.001). Median peak pressures were 54.6, 66 and 66.6 cm H2O respectively (P < 0.001). Otten et al. [14] reported median expired tidal volume percentages of 31% for the one-handed technique and 85% for both the two-handed and modified two-handed techniques. The median differences between the one-handed and two-handed techniques were 47% and 56% respectively. Taken together, these studies show that how the mask is held strongly influences ventilation.

In this study the EO technique gave better tidal volume, better minute ventilation and a lower incidence of audible mask leak than the EC technique in novice hands. Audible epigastric leak did not differ between the techniques. The EO technique is therefore a simple, effective alternative to the traditional EC grip for single-handed mask holding by inexperienced personnel, and it merits inclusion in airway training programmes.

Conclusion

In our study, we conclude that the E-O technique provides a better mask seal than the E-C clamp technique during face-mask ventilation performed by novice practitioners in anaesthetised and paralysed patients.

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