Comparing the efficacy of modified thenar eminence technique with conventional thenar eminence technique of mask ventilation during induction of general anaesthesia – A randomised crossover study

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ABSTRACT

Background and Aims: Mask ventilation is one of the important skills required for successful airway management. Following the induction of general anaesthesia, there could be airway obstruction due to fall back of the tongue or soft palate. This obstruction could be overcome by manoeuvring the mandible or inserting airways. The primary objective of the study was to compare the efficacy of modified thenar eminence technique of mask ventilation in improving expired tidal volume ($V_T$) over conventional thenar eminence technique and the secondary objective was to compare peak airway pressure ($P_{max}$) and ease of mask ventilation between the two techniques. Methods: Seventy-six patients were randomised into group M and group C. In group M, the modified thenar eminence technique was performed for five consecutive breaths followed by conventional technique, and vice versa was followed in group C. In each breath, $V_T$, $P_{max}$, and end-tidal carbon dioxide were noted. Participants reported the ease of ventilation score using the Likert scale for each technique. Results: $V_T$ was significantly more in modified thenar eminence technique than conventional technique [mean ± standard deviation, 370 ± 55 ml versus 313 ± 50 ml, $P=0.01$]. Ease of ventilation score [median 1.70 (interquartile range (1–2)) versus 2.3 (2–3), $P=0.01$] showed that modified technique was easier compared to conventional technique. Conclusion: Modified thenar eminence technique of mask ventilation is superior to the conventional technique in terms of $V_T$ and ease of ventilation in the unanticipated difficult airway.

Key words: Conventional thenar eminence technique, mask ventilation, modified thenar eminence technique

INTRODUCTION

Mask ventilation is one of the necessary abilities required for successful airway management. Maintenance of airway patency and oxygenation are the major goals of mask ventilation.¹ Difficult mask ventilation could happen in four out of 1,000 patients.² When the conventional mask ventilation is difficult, several alternative techniques have been described. One such technique is the conventional thenar eminence. In this technique, downward pressure is applied with thenar eminences of both hands while the four fingers of each hand pull the jaw towards the mask.³,⁴ Since the jaw is pulled upward towards the mask, it leads to closure of the mouth resulting in airway obstruction at the oropharynx.

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However, this obstruction could possibly be overcome by the use of an appropriately sized oro-pharyngeal airway. This may not be successful in all patients.\[6\] The combination of upward force at the chin with a forward and downward movement of the mandible would open the mouth and also the oropharynx.\[7,8\] We hypothesised that this proposed modified technique of mask ventilation would result in increased ventilation in terms of expired tidal volume ($V_{T_E}$). In this technique, downward and forward force is given by the thumb at the chin to facilitate mouth opening apart from the jaw thrust and thenar eminence pressure. This randomised crossover trial was designed to evaluate the efficacy of modified thenar eminence technique of mask ventilation. The primary objective of the study was to compare the efficacy of modified thenar eminence technique of mask ventilation in improving $V_{T_E}$ over the conventional thenar eminence technique. The secondary objective was to compare peak airway pressure ($P_{MAX}$) and ease of mask ventilation between the two techniques.

**METHODS**

This study was conducted in a tertiary care referral institute from September 2017 to December 2018. The study was approved by the university’s institute ethics committee (Human Studies) [JIP/IEC/2016/1080] and written informed consent was obtained from all subjects who participated in the trial. The trial was registered prior to patient enrolment at the Clinical Trial Registry of India (CTRI/2017/08/009373) and was done in accordance with the principles of the declaration of Helsinki. The sample size was calculated with an alpha error of 5%, power of 80%, mean [standard deviation (SD)] of the expired tidal volume of conventional two-handed thenar eminence technique of 8.6 (2.3) ml/kg and a mean difference of 10% using stata version 13 [Stata Corp LLC, California]. The estimated sample size in each group was 38 and the total sample size was 76.

Patients aged between 18 and 70 years scheduled for elective surgery under general anaesthesia were enroled in the study. Patients who had maxillo-mandibular deformities (e.g. micrognathia, retrognathia), full stomach, and known gastro-oesophageal disorder, emergency surgery and pregnant patients were excluded from the study. All patients were premedicated with famotidine 20 mg and diazepam 5 mg orally on the forenight and on the day of surgery.

On the day of surgery, simple randomisation was done based on computer generated random numbers. Allocation concealment was done using sequentially numbered opaque sealed envelope technique. Patients were randomised into group C and group M. In Group C, conventional thenar eminence technique [Figure 1a] was performed first followed by modified thenar eminence technique [Figure 1b]. In group M, modified thenar eminence technique was performed first followed by conventional thenar eminence technique.

Modified thenar eminence technique is performed by placing the patient’s head and neck similar to the conventional thenar eminence technique which is a sniffing position. The anaesthesiologist extends the patient’s head. The jaw thrust is then applied using the fingers of both hands and the mouth is opened using both the thumbs by placing it in the lower jaw. While maintaining the mouth in the open position, the assistant keeps the mask over the face. Then the anaesthesiologist keeps the thenar eminence of both hands over the mask and pressure is applied to obtain the tight seal. During mask ventilation, the anaesthesiologist maintains this technique by three manoeuvres. First, the firm downward pressure is applied over the mask by both thenar eminences to have a tight seal. Second, downward and forward pressure is applied in the lower jaw by both thumbs to keep the mouth open and also to have a good seal between the mask and lower jaw. Finally, firm pressure is applied over the angle of the mandible to provide adequate jaw thrust. Thus, the chin lift is avoided in the modified thenar eminence technique to provide adequate mouth opening thereby improving the ventilation.

In the operation theatre, pulse oximetry, electrocardiogram, end-tidal carbon dioxide ($ETCO_2$) and non-invasive blood pressure monitors were

![Figure 1](image_url)
established. Patient was preoxygenated for three minutes. General anaesthesia was induced with 1–2 µg/kg of fentanyl and 3–6 mg/kg of thiopentone sodium. Muscle paralysis was achieved with vecuronium 80–100 µg/kg. A clear transparent disposable plastic face mask of size 3 or 4 with a high-volume and low-pressure cuff was used in the study. The patient was mask ventilated for three minutes by the attending anaesthesiologist who was not participating in the study. Meanwhile, the ventilator was preset in volume control mode to deliver 8 ml/kg of tidal volume at the rate of 12 breaths/min with no additional positive end-expiratory pressure. During the study period, the initial few breaths were allowed for the VTf to stabilise and the study parameters were noted for five consecutive breaths. The average of five breaths was used in the statistical analysis. An anaesthesiology resident (experience of more than one year) mask ventilated the patient using the first technique according to randomisation for five consecutive breaths. Then the attending anaesthesiologist mask ventilated (their comfortable technique) the patient for one minute to maintain ETCO2 between 35 mmHg and 45 mmHg. The same anaesthesiology resident then mask ventilated the patient using the second technique for five consecutive breaths. Another resident who was not involved in the study auscultated over the patient’s epigastrium to detect gastric insufflations during the study period. Audible leak around the mask was assessed as either present or absent and recorded as such. The attending anaesthesiologist recorded all data manually from the ventilator readout. The VTf, P MAX and ETCO2 for each breath were noted for all the five consecutive breaths. Ease of ventilation score was also assessed between the two techniques using the Likert scale (easy – 1, moderate – 2 and difficult – 3) at the end of the study.

Statistical analysis was done by using Statistical Package for the Social Sciences software version 19 [SPSS Inc., Chicago, USA]. Categorical variables included gender, American Society of Anesthesiologists physical status class and modified Mallampati score which were expressed as proportion. Continuous variables such as age, height, weight, body mass index (BMI), VTf, P MAX, ETCO2 were expressed as mean ± standard deviation. Normality testing was done using Kolmogorov Smirnov test, and all parameters except ease of ventilation score were normally distributed. VTf and P MAX were analysed using paired t-test. The ease of ventilation score was analysed using Wilcoxon signed rank test expressed in mean rank with interquartile range (IQR).

**RESULTS**

A total of 78 patients were assessed for eligibility among which two were excluded (one patient did not give consent and other patient did not meet inclusion criteria). A total of 76 patients were randomised into two groups. Data from all 76 patients was collected and analysed [Figure 2]. Among 76 patients, 34 (44.7%) were male and 42 (55.3%) were female [Table 1]. The mean age was 38 years with an average BMI of 21.6 kg/m². The VTf was significantly more in the modified thenar eminence technique than in the conventional thenar eminence technique [370 ± 55 ml versus 313 ± 50 ml, \( P = 0.01 \)] [Tables 2 and 3]. The VTE was correlated with ETCO2 which was 33 ± 3 in the modified thenar eminence technique and 31 ± 3 in the conventional thenar eminence technique [\( P = 0.01 \)] [Tables 2 and 3]. The P MAX was 15.2 ± 2.2 cm H2O in the modified thenar eminence technique and 15.1 ± 2.1 cm H2O in the conventional thenar eminence technique which was comparable [\( P = 0.39 \)] [Tables 2 and 3]. Based on the ease of ventilation for operator score using Likert scale, we found that the modified thenar eminence technique was easier for mask ventilation compared to the conventional thenar eminence technique [1.70 (1–2) versus 2.3 (2–3)] [Table 4]. None of the patients had audible leak around the mask or gastric leak.

| Table 1: Demographics and other characteristics |
| Parameter | Value |
| Age (years) | 38.49±12.71 |
| Height (cm) | 161.13±6.19 |
| Weight (kg) | 56.33±9.39 |
| BMI (kg/m²) | 21.6±2.74 |
| Gender (M/F) (%) | 34 (44.7%)/42 (55.3%) |
| ASA (1/2) (%) physical status | 56 (73.6%)/20 (26.3%) |
| MMP (1/2/3) (%) class | 37 (48.6%)/36 (47.3%)/3 (3.9%) |

**Table 2: Outcome parameters**

| Outcome Parameters | Modified thenar eminence technique (n=76) | Conventional thenar eminence technique (n=76) | \( P \) |
| Expired tidal volume (ml) | 370±55 | 313±50 | 0.01 |
| Peak airway pressure (cm H2O) | 15.2±2.2 | 15.1±2.1 | 0.39 |
| ETCO2 (mmHg) | 33±3 | 31±3 | 0.01 |

All values expressed as terms of mean±standard deviation; ETCO2 – end-tidal carbon dioxide, \( n \) – number; \( P < 0.05 \) was considered as statistically significant.
DISCUSSION

Our results demonstrated that the modified thenar eminence technique had statistically significant VT than the conventional thenar eminence technique. The P\textsubscript{MAX} was comparable between the modified thenar eminence technique and the conventional thenar eminence technique. The secondary outcome in our study was the ease of ventilation score assessed using Likert scale which showed that modified thenar eminence technique was easier compared to the conventional thenar eminence technique.

Several studies have reported that in the supine position, after the induction of general anaesthesia, the tongue falls posteriorly leading to airway obstruction.\cite{6,7,9,10} Hillman et al.\cite{10} found that the site of upper airway obstruction was at the level of the velopharynx. Extension of the neck, forward displacement of the mandible and keeping the mouth open are the ways in which the airway patency can be maintained.\cite{9,10} The mouth opening was an important component in mouth to mouth breathing while resuscitating cardiac arrest patients as demonstrated by Safar et al.\cite{11} Soleimanpour et al.\cite{12,13} compared
three techniques of mask ventilation between novice and experienced operators in a mannequin. The novice group did ‘E-O’ grip better than other techniques. It was the operator who makes the two-handed mask ventilation difficult in normal airway patients by not getting an adequate seal leading to difficult mask ventilation. In our study, to measure the efficacy of mask ventilation between the two techniques, we used the VT$_E$. Joffe et al.$^{[14]}$ compared the two-handed technique of mask ventilation with the one-handed technique using mean VT$_E$.

In our study, the P$_{MAX}$ values between the two techniques were not statistically significant. In a study conducted by Gerstein et al.$^{[5]}$, to study the effectiveness of various mask ventilation techniques among healthcare professionals, a no statistical significance of P$_{MAX}$ was found between the “C-E” grip [placing the middle, ring, and little fingers (the letter “E”) under the mandible and pulling the mandible upward, while the thumbs and index fingers create a “C” and then press down against the mask] and the thenar eminence (V-E) technique. We do not have any possible explanation for the comparable P$_{MAX}$.

We had used randomised crossover design in our study to evaluate the efficacy of mask ventilation of both techniques in the same patient. Few other studies have also used the randomised crossover design to compare the efficacy of one technique over another technique of mask ventilation.$^{[14,15]}$ The modified thenar eminence technique delivered greater VT$_E$ (370 ± 55 mL versus 313 ± 50 mL, P = 0.01) than the conventional thenar eminence technique in our study. The greater VT$_E$ obtained with the modified thenar eminence technique was due to better airway patency with the modified technique compared to the conventional technique. Due to the forward and downward movement of mandible with mouth open, there will be increase in both retro lingual and retro palatal cross-sectional area which results in lesser airway resistance.$^{[15,16]}$ Our results are substantiated by a study conducted by Fei et al.$^{[15]}$ where two-handed mask ventilation in apnoeic obese individuals was compared using VT$_E$ as a primary outcome.

Though this study was conducted in a randomised crossover design in a well-controlled setting, it also has few limitations. First, we had included only normal patients and excluded those with an anticipated difficult airway. It is well known that obesity is a risk factor for difficult mask ventilation. Hence, the efficacy of the modified thenar eminence technique over conventional thenar eminence technique might be overestimated in an obese population. Second, the modified thenar eminence technique was not the most commonly used hand grip among anaesthesiologists. Although ventilation with modified technique was much easier than the conventional technique in our study in the normal airway population, future studies are needed in other populations to substantiate it. Third, though VT$_E$ was statistically significant, we do not have any possible explanation for comparable P$_{MAX}$ between the two techniques.

**CONCLUSION**

Modified thenar eminence technique is superior to conventional thenar eminence technique in terms of VT$_E$ and ease of ventilation for mask ventilation during the induction of anaesthesia in unanticipated difficult airway patients. Hence, we suggest the use of the modified thenar eminence technique to achieve a higher success rate in maintaining upper airway patency and ventilation during unanticipated difficult mask ventilation.

**Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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**Conflicts of interest**

There are no conflicts of interest.

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