EVALUATION OF TIDAL VOLUME VARIATIONS FOLLOWING NEUROMUSCULAR BLOCKADE DURING MASK VENTILATION UNDER GENERAL ANAESTHESIA

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ABSTRACT

Background: Effective face mask ventilation (FMV) is a critical component of safe airway management during induction of general anaesthesia. Neuromuscular blockade (NMB) is routinely used to facilitate tracheal intubation; however, its effect on mask ventilation and tidal volume delivery remains variable and clinically important. This study evaluates the impact of neuromuscular blockade on tidal volume changes during FMV.

Methodology: This prospective observational study was conducted in 87 adult patients aged >18 years of ASA physical status I and II undergoing elective surgeries under general anaesthesia requiring neuromuscular blockade. Patients with anticipated difficult airway, BMI >35 kg/m², respiratory disease, or neuromuscular disorders were excluded. After induction of anaesthesia, baseline tidal volumes were recorded during mask ventilation, followed by administration of vecuronium (0.1 mg/kg). Tidal volume measurements were repeated after confirmation of neuromuscular blockade using train-of-four monitoring. Data were analysed using SPSS software, and statistical significance was set at $p<0.05$.

Results: Most patients were females (58.6%) and overweight/obese (65%). Majority had Mallampati class II and Grade 1–2 mask ventilation before NMB. Following neuromuscular blockade, tidal volume showed significant improvement in a subset of patients, while others demonstrated minimal change. Overall, ventilation remained stable and no cases of complete ventilation failure were observed.

Conclusion: Neuromuscular blockade influences tidal volume during FMV and may improve ventilation in selected patients. Careful assessment is essential before administration to ensure airway safety during induction.

Keywords: Neuromuscular Blockade, Face Mask Ventilation, Tidal Volume, General Anaesthesia, Airway Management.

INTRODUCTION

Effective airway management is a cornerstone of safe anaesthetic practice, and face mask ventilation (FMV) remains an essential skill in the induction of general anaesthesia. The administration of neuromuscular blocking drugs (NMBDs) is commonly associated with a period of apnoea during which adequate ventilation must be ensured until tracheal intubation is achieved. Failure to maintain effective mask ventilation following neuromuscular blockade can rapidly lead to hypoxaemia and significant morbidity, particularly in situations where tracheal intubation is also difficult or impossible.[1] For this reason, many anaesthesiologists traditionally confirm the ability to perform effective bag-and-mask ventilation before administering neuromuscular blockers.

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If mask ventilation is adequate, NMBDs are then administered to facilitate optimal intubating conditions. Conversely, if FMV is found to be inadequate following induction of anaesthesia, the patient may be awakened and alternative airway management strategies considered. However, in practice, recovery of adequate spontaneous ventilation at this stage may be difficult, as induction agents and adjunct drugs used to facilitate ventilation may already contribute to upper airway collapse and respiratory depression, thereby increasing the risk of rapid desaturation.[2]
Interestingly, neuromuscular blockade may also improve mask ventilation in certain clinical situations. Conditions such as laryngospasm and opioid-induced chest wall rigidity can significantly impair ventilation, and administration of NMBDs can relieve these airway and chest wall muscle contractions, thereby improving FMV.[3] Furthermore, in patients with difficult airway anatomy or increased airway resistance, paralysis may facilitate both mask ventilation and subsequent

tracheal intubation by eliminating involuntary muscle tone that contributes to airway obstruction.

Despite its widespread use, the decision to administer neuromuscular blockers prior to confirming ease of mask ventilation remains a subject of ongoing debate. Concerns persist regarding the potential risk of "cannot ventilate, cannot intubate" scenarios following paralysis. On the other hand, delaying neuromuscular blockade may result in suboptimal intubating conditions, increased airway trauma, and prolonged hypoxia risk during repeated airway attempts.

In addition to clinical decision-making, recent interest has emerged in understanding the physiological impact of neuromuscular blockade on ventilatory parameters during FMV. In particular, changes in tidal volume during mask ventilation may provide objective insight into airway patency and ventilation efficiency before and after neuromuscular blockade. Such measurements could help quantify the effect of muscle relaxation on upper airway mechanics and overall ventilation quality.

Therefore, the present study was designed to evaluate the effect of neuromuscular blockade on tidal volume changes during face mask ventilation in patients undergoing general anaesthesia. The study aims to provide objective evidence regarding whether neuromuscular blockade improves, worsens, or has no significant effect on mask ventilation parameters, thereby contributing to safer airway management strategies in clinical anaesthesia practice.

Aim

To evaluate the effect of neuromuscular blockade on tidal volume changes during face mask ventilation in patients undergoing general anaesthesia.

Objectives

1. To measure and compare tidal volume during face mask ventilation before and after administration of neuromuscular blocking agents.
2. To assess the effect of neuromuscular blockade on the ease and adequacy of bag-and-mask ventilation.
3. To evaluate changes in ventilatory parameters associated with neuromuscular blockade during induction of general anaesthesia.
4. To contribute evidence supporting safer airway management decisions regarding timing of neuromuscular blocker administration.

METHEDOLOGY

This prospective observational study was conducted in the Department of Anaesthesiology at Sree Mookambika Institute of Medical Sciences, Kulasekharam, during the period from February 2025 to March 2026 after obtaining institutional ethical committee approval and written informed consent from each patient. A total of 87 adult patients aged more than 18 years, belonging to American Society of Anesthesiologists (ASA) physical status I and II, scheduled for elective surgeries under general anaesthesia requiring neuromuscular blocking drugs (NBD) for facilitation of tracheal intubation were included in the study. Patients in whom neuromuscular blockade was not indicated, those with anticipated difficult mask ventilation including rapid sequence induction or known difficult airway, patients with respiratory disease, body mass index (BMI) >35 kg/m², neuromuscular disorders, craniofacial abnormalities, and those who refused consent were excluded from the study.

All patients underwent preoperative evaluation on the previous day and were kept nil per oral according to standard guidelines. Premedication included oral pantoprazole 40 mg and alprazolam 0.5 mg administered the night before and two hours prior to surgery. On the day of surgery, patients were reassessed and standard monitors including ECG, non-invasive blood pressure, and pulse oximetry were applied in the operating room. Intravenous access was secured, and premedication was given with inj. Midazolam 0.02–0.05 mg/kg IV, inj. Glycopyrrolate 0.005 mg/kg IV, inj. Ondansetron 0.1 mg/kg IV, and inj. Fentanyl 1–2 µg/kg IV. After adequate preoxygenation, anaesthesia was induced with inj. Propofol 2–3 mg/kg preceded by inj. Lignocaine 1.5 mg/kg IV.

Mask ventilation was performed in the "sniffing position" and tidal volume was delivered using pressure-controlled ventilation at 15 cm H_2O with a respiratory rate of 12 breaths per minute. The initial mask ventilation grade was assessed using the Han classification. Ventilation was optimized using oropharyngeal airway insertion, jaw thrust, and two-hand mask technique when required. Anaesthesia was maintained with sevoflurane 2% in oxygen with a fresh gas flow of 6 L/min. Baseline expired tidal volumes were recorded for 2 minutes prior to neuromuscular blockade. Vecuronium 0.1 mg/kg IV was then administered, and onset of neuromuscular blockade was confirmed using train-of-four monitoring. After confirmation of complete blockade, expired tidal volumes were recorded for an additional 3 minutes, and mean tidal volumes were calculated before and after neuromuscular blockade.

The primary outcome was change in expired tidal volume following administration of neuromuscular blocking agent, with a ≥20% improvement considered clinically significant. Data were entered into Microsoft Excel and analysed using SPSS software version 22.0. Continuous variables such as tidal volume were expressed as mean ± standard deviation and compared using paired and unpaired t-tests as appropriate. Categorical variables such as mask ventilation grade were expressed as frequency and percentage and analysed using Chi-square test or Fisher's exact test. A p-value of less than 0.05 was considered statistically significant.

RESULT

Table 1: Han Scale for Mask Ventilation

	Description
Grade 1	Ventilated by mask single- handed
Grade 2	Difficult to ventilate, oropharyngeal airway inserted
Grade 3	Ventilated by mask with jaw thrust, airway manoeuvres and two-handed technique
Grade 4	Unable to ventilate

Table 2: Distribution of Study Participants Based on the Gender, N=87

Gender	**Frequency (%)**
Male	36(41.4)
Female	51(58.6)

Male gender distribution was found to be 41% and the female gender was found to be 59% among the study population. Distribution of study participants based on the BMI category

Table 3: Distribution of Study Participants Based on the BMI Category, N=87

BMI category	**Frequency (%)**
Underweight (<18.5)	2(2.3)
Normal (18.5-24.9)	29(33.3)
Overweight (25-29.9)	25(28.7)
Obesity class I (30- 34.9)	31(35.6)

More than half (65%) of study population had BMI >25(obesity class I of 36%, overweight of 29%) followed by normal BMI in 33% and underweight in 2%, of the study population.

Table 4: Distribution of the Study Population on the Basis of Mallampati Score, N=87

Mallampati class	**Frequency (%)**
1	22(25.3)
2	57(65.5)
3	8(9.2)
4	0

On the basis of the Mallampati class it was found that 66% of the patients had a score of 2, followed by 25% with score 1 and 9% of the people had score of 3.

Table 5: Distribution of Study Participants Based on Difficult Airway Markers, N=87

Characters	**Frequency (%)**
Edentulous	17(19.5)
Presence of beard	6(6.9)
History of snoring	19(21.8)
Receding jaw	3(3.4)
Limited neck movement	2(2.3)

On the basis of the history given by the study population, it was found that 22% had history of snoring and 20% had evidence of being edentulous. In 7% of the people, beard was present. Receding jaw was seen in 3.4 % of the population followed by limited neck movements in 2.3 % of the individuals.

Table 6: Distribution of Study Participants Based on Grading Of Mask Ventilation before Neuromuscular Blockade, N=87

Grading of mask ventilation	Frequency (%)
Grade 1	30(34.5)
Grade 2	43(49.4)
Grade 3	14(16.1)
Grade 4	0

On the basis of grading of mask ventilation before neuromuscular blockade, 49% of the study people were in grade 2 followed by the grade 1 and 16% in grade 3. Distribution of study participants-based grade of mask ventilation before administrating the NMB, N=87

Table 7: Distribution of Study Participants-Based Grade of Mask Ventilation before Administrating the NMB, N=87

Grade of mask ventilation	Underweight	Normal	Overweight	Obesity class 1
Grade 1	2(6.7%)	23(76.7%)	5(16.7%)	0
Grade 2	0	6(14%)	19(44.2%)	18(41.9%)
Grade 3	0	0	1(7.1%)	13(92.9%)
Grade 4	0	0	0	0

Among patients with BMI ≤25 kg.m2, 80% were classified as grade 1 mask ventilation. On the other half, ie patients with BMI ≥ 25 kg.m2, 91% were classified as grade 2&3 mask ventilation.

Table 8: Distribution of Study Population Based on Neck Circumference and Grades of MV, N=87

Grades	Neck circumference<40 cm (%)	Neck circumference>40 cm (%)
Grade 1	30(100)	0
Grade 2	39(90.7)	4(9.3)
Grade 3	4(28.6)	10(71.4)

71% of patients with neck circumference >40 was classified as grade 3 mask ventilation.

Distribution of study participants based on Cormack Lehane laryngoscopy grade, N=87

Table 9: Distribution of Study Participants Based on Cormack Lehane Laryngoscopy Grade, N=87

Laryngoscope grade	Frequency (%)
1	51(58.6)
2a	27(31)
2b	7(8)
3	2(2.3)
4	0

On the basis laryngoscopic grading, 59% patients were grade 1, 31% grade 2a, 8% for grade 2b. Only 2% of patients were grade 3.

Table 10: Distribution of Study Population on the Basis of Expired Tidal Volume (TVE) Before and After Neuromuscular Blockade (NMB), N=87

TVE	Mean (SD)
TVE before NMB	451.9(61.5)
TVE 1 minute after NMB	514.1(75)
TVE 2 minutes after NMB	560.6(72.5)
TVE 3 minutes after NMB	597.9(81.1)
Mean TVE after NMB	557.6(72.5)

The mean (SD) expired tidal volume was calculated before and after the administration of neuromuscular blockade which was found to be 451.9(61.5) and 557.6(72.5) respectively. TVE was assessed at 1 min, 2 mins and 3 mins which was found to be 514.1(75), 560.6(72.5) and 597.9(81.1) respectively.

Table 11: Distribution of Study Population on the Basis of Mean Difference Between the Expired Tidal Volume (TVE) Before and After Neuromuscular Blockade (NMB), N=87

TVE	Mean difference	P value
TVE before NMB and TVE after 1 minute of NMB	-62.3	0.0001
TVE before NMB and TVE after 2 minutes of NMB	-108.7	0.0001
TVE before NMB and TVE after 3 minutes of NMB	-146.1	0.0001
TVE before NMB and mean TVE after NMB	-105.7	0.0001

The mean difference between TVE before the NMB administration and TVE after NMB at 1 min,2 min and 3 mins was found to be -62.3, -108.7 and -146.1 respectively. The mean difference was found to statistically significant between the points of assessment at various time points.

DISCUSSION

In the present study, 87 adult patients undergoing general anaesthesia with neuromuscular blockade were evaluated to assess the effect of neuromuscular blocking agents on mask ventilation parameters and tidal volume changes. The demographic profile showed a female predominance (58.6%), with males comprising 41.4% of the study population. This distribution is comparable to routine elective surgical populations, where female patients often predominate due to higher rates of abdominal and gynaecological procedures.

Body mass index analysis revealed that nearly two-thirds of the patients had BMI >25 kg/m², indicating a significant proportion of overweight and obese individuals. Obesity is a well-recognized factor associated with difficult mask ventilation due to reduced functional residual capacity, increased airway collapsibility, and decreased pulmonary compliance.[16] This distribution therefore strengthens the relevance of the study in evaluating airway dynamics in a higher-risk population.

Airway assessment using Mallampati classification showed that the majority of patients belonged to class II (65.5%), followed by class I (25.3%), and class III (9.2%). No patients were in class IV. Mallampati grading remains a useful predictor of potential difficult airway, although its sensitivity alone is limited.[17] In the present study, most patients had relatively favourable airway anatomy, which allowed for standardized assessment of mask ventilation before and after neuromuscular blockade.

Difficult airway markers such as snoring history (21.8%), edentulous status (19.5%), beard presence (6.9%), receding jaw (3.4%), and limited neck movement (2.3%) were observed in a subset of patients. These factors are known to contribute to upper airway obstruction and increased difficulty in achieving adequate mask ventilation.[18] Despite the presence of such risk factors in a proportion of patients, most cases could still be ventilated with standard airway maneuvers, indicating effective airway optimization during induction.

The grading of mask ventilation prior to neuromuscular blockade demonstrated that nearly half of the patients (49.4%) were in Grade 2, followed by Grade 1 in 34.5% and Grade 3 in 16.1%, with no Grade 4 cases. This indicates that the majority of patients had either easy or only moderately difficult mask ventilation prior to administration of neuromuscular blockers. Similar findings have been reported in previous studies, where baseline mask ventilation difficulty is generally mild in elective surgical populations.[19]

The presence of Grade 2 and Grade 3 mask ventilation in a significant proportion of patients highlights the importance of assessing the effect of neuromuscular blockade on ventilation quality. It is clinically relevant because neuromuscular blockers may either worsen ventilation in cases of airway collapse or improve it by relieving laryngospasm, chest wall rigidity, or upper airway obstruction.[20]

Overall, the baseline characteristics of the study population demonstrate a representative cohort with mixed airway risk profiles, making the findings applicable to routine anaesthetic practice. The distribution of BMI, Mallampati class, and airway difficulty markers supports the validity of evaluating tidal volume changes as an objective measure of ventilation improvement following neuromuscular blockade.

CONCLUSION

The present study demonstrates that neuromuscular blockade has a significant impact on tidal volume during face mask ventilation in patients undergoing general anaesthesia. The study population showed a varied distribution of airway characteristics, with a majority of patients having BMI above normal range and Mallampati grade I–II, indicating a mixed airway risk profile. Most patients had Grade 1 and Grade 2 mask ventilation prior to neuromuscular blockade, suggesting generally adequate baseline ventilation with some degree of variability.

The findings suggest that neuromuscular blockade may influence the ease and efficiency of mask ventilation, with potential improvement in tidal volume in selected patients by relieving airway obstruction and muscle tone. However, in patients with existing airway compromise, careful monitoring remains essential due to the risk of worsening ventilation after paralysis. Overall, neuromuscular blockade remains a double-edged intervention that can either facilitate or impair mask ventilation depending on the underlying airway dynamics.

This study supports the importance of individualised assessment of mask ventilation before and after neuromuscular blockade. Objective monitoring of tidal volume may serve as a useful parameter in evaluating ventilation adequacy during induction of anaesthesia. Further large-scale studies are recommended to better define predictors of improvement or deterioration in ventilation following neuromuscular blockade and to enhance airway safety strategies in clinical practice.

REFERENCES

1. American Society of Anesthesiologists Task Force. Practice guidelines for management of the difficult airway. Anesthesiology. 2013;118(2):251-70.
2. Naguib M, Brull SJ. Update on neuromuscular blockade and reversal agents. Anesthesiology. 2018;128(1):34-54.
3. Orebaugh SL. Difficult mask ventilation and neuromuscular blockade. Anesth Analg. 2009;109(6):1897-903.
4. Kheterpal S, Han R, Tremper KK, et al. Incidence and predictors of difficult mask ventilation. Anesthesiology. 2006;105(5):885-91.
5. Murphy GS, Szokol JW. Residual neuromuscular blockade and respiratory complications. Anesth Analg. 2011;112(2):362-7.
6. Kheterpal S, Martin L, Shanks AM, Tremper KK. Prediction and outcomes of impossible mask ventilation. Anesthesiology. 2009;110(4):891-897.
7. Naguib M, Brull SJ. Update on neuromuscular blockade and reversal agents. Anesthesiology. 2018;128(1):34-54.
8. Lundstrøm LH, et al. Predictive factors for difficult mask ventilation. Acta Anaesthesiol Scand. 2009;53(2):173-180.
9. American Society of Anesthesiologists Task Force. Practice guidelines for management of the difficult airway. Anesthesiology. 2022;136(1):31-81.
10. El-Orbany M, Woehlck H. Difficult mask ventilation. Anesth Analg. 2009;109(6):1870-1880.

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